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ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT *

By C. F. HIRSHFELD, Detroit Edison Company

We are living in a period in which it has become the style to question with the utmost freedom practically everything having to do with the life of man. Religious forms and teachings, social organizations and values, economic theories and practices, the significance of family life and family ties, physical science which was thought by many to rest on an absolutely unassailable foundation, all these, and more, are being subjected to an inquisition of unprecedented character and extent.

It is commonly held that, out of this chaos, there is to emerge a new social, economic and cultural order resulting from a revaluation of that which has been and a reorientation with respect to that which is to be. I find myself unable to travel with the mob in these respects. To me we shall end by discovering once more the reality and significance of certain eternal verities, or at least verities which shall be such for so long a time that for our present purposes we may regard them as eternal.

History does not show any case in which an existing order, an existing culture or an existing anything else of significance has been thrown away over night and successfully replaced by new somethings created full grown from the brain of man. And I do not believe that we have suddenly become such superhuman individuals that we can accomplish, successfully, such a superhuman task.

I feel very certain that we shall shortly realize that man is man, that, in spite of a large admixture of idealism in the mass, he is actuated very largely by considerations of self interest as an individual. Moreover, I believe that we shall also realize that no workable social organization can be produced which does not take this into account and therefore provide for the rather generous exercise of the individualistic urge. And further, I am positive that we shall rediscover the impracticability of attempting to repeal, by fiat, laws of economics and of human relations which, after all, are but expressions of the natural psychological reactions of man to certain conditions.

If the industrialist insists on producing more shoes or more automobiles or more anything else than he can sell on the average,

* Address before Middle Atlantic Section of S. P. E. E., November 11, 1933.

no governmental or economic juggling is, in the end, going to make such actions anything other than poor judgment and economic waste. And if the sacred farmer insists on producing more wheat or more cotton or more hogs or more anything else than the market requires no governmentally hatched and administered plan is going to make the world pay more than the product is worth to it.

You may wonder why I preface my address on the Engineers' Council for Professional Development with thoughts of this character. I have two reasons and both seem good to me.

First, if we are to have any such tremendous social and economic upheaval as is being freely predicted and if out of it are to come such new forms of social and economic practice as have been freely predicted it would be foolish to carry on at the present time any such movement as this Council stands for. We might better wait to discover the characteristics of the new order and then attempt to determine what might be done to the best advantage under such conditions.

Second, if we are, as I suspect, to return in the end to essentially what we had before, the sooner we can get a large part of the educated and potentially powerful and influential fraction of our population thinking sane thoughts, based upon an appreciation of human nature and of human relations as they have shown themselves historically to be, and undoubtedly still are, the better. It is practically the function of the Council to produce just such a result with respect to some part of that fraction.

Therefore, gentlemen, please realize that what I say to you to day is based upon the firm belief that when all the political fireworks and minority smoke screens and theorists' isms have cleared away we shall find ourselves in much the same sort of a world as we grew accustomed to before we learned, en masse, to spend more than we had or could get and before we grew accustomed to believing that politically actuated congressmen and cloistered bureaucrats could solve problems and administer activities which tax the best brains that we have.

Looking back over the world that has been I think it very evident that the individual whom we call the engineer has been always present, first in more or less embryonic form and later in what may be called the stages of childhood and of adolescence. To me he is just about emerging from the state of adolescence at the present time.

Let me point out to you that he has only recently discovered the tremendous powers that he possesses and that, in characteristic adolescent fashion he has used them without any great amount of thought to the ultimate results of such use. Through his productivity he has radically changed the life of the human family. Very

little is now done in the way in which it was done only a short time ago as time is reckoned in terms of human history.

And now this virile but reckless youth appears to me to have arrived at the place where he must become grown up; where he must recognize his responsibilities to the other parts of the human family; where he must study well the probable effects of his seeds before he plants them and must accept some measure of responsibility for his offspring, their doings and their influence.

You can see many signs of this if you will but look. The public press, which is always a good reflector though often a poor evaluator, is fairly consistent in blaming many of our present ills upon the engineer. All appear to agree that he has wrought well but irresponsibly. The States have, in many cases, decided that his works are of such tremendous significance and fraught with such potentialities for evil as well as for good, that it is necessary to use their police power to put some measure of control upon his activities. The industrialists and others who hire and who use engineers in large numbers are complaining that he is too single tracked an individual, that, in general, he knows one thing well and most others not at all. You educators of engineers have become cognizant of the fact that the product of yesterday does not measure up to the demands of to-day and are working diligently, and sometimes frantically, to discover how to produce the product that seems to be demanded. As I see it, the engineer has had a comparatively easy time of it. He has dealt with problems amenable to factual attack. To be sure, judgment has been required frequently in large measure but, even then, it had a fairly substantial factual basis. Working in this way, he has advanced our civilization lopsidedly in that he had outstripped the workers in other fields in which factual methods of attack have not been developed, or, possibly, in some of which they are not applicable.

There is nothing really alarming in this. Human progress has always been by means of wedges driven ahead of the general line of progress. The danger comes in permitting any wedge to get too far out ahead of the line. And, curiously, the human social organism seems to have an inherent reaction which prevents such catastrophes. The wedge is either lopped off or the line catches up. In the present case I am satisfied that we shall discover that we cannot get along without the engineer and his advances, therefore the wedge cannot be lopped off. Ergo, we shall have to maneuver so that the line catches up.

In that last sentence you have my own reason for being as vitally interested as I am in the Engineers' Council for Professional Development. To my mind it is not a device to aggrandize the engineer. It is a device which may be expected to assist in

making the engineer the kind of broad minded, well educated and rounded individual necessary to do his share in pulling the line forward so that the wedge may not get too dangerously far ahead.

Now, what is this Engineers' Council for Professional Development? It is a joint body created by seven previously existing national organizations, namely

American Society of Civil Engineers,
American Institute of Mining Engineers,
American Institute of Electrical Engineers,
American Society of Mechanical Engineers,
American Institute of Chemical Engineers,
Society for the Promotion of Engineering Education,
and
National Council of State Boards of Engineering Examiners.

It consists of representatives appointed by and from these organizations, three from each of them, making a body of twenty-one members. An Executive Committee of one third that size serves as a convenient body for the handling of matters not requiring the immediate attention of the larger Council.

Organization was completed about a year ago and the first annual meeting was held in New York last month. Therefore, I am telling you about a going organization, not something that we are still dreaming about.

You will observe that the bodies having membership in the Council represent respectively the professional and technical, the educational and the legal aspects of the engineer's life. Such representation was decided on after mature deliberation and is believed to be the minimum that is acceptable and workable. By this I mean that any less comprehensive representation would place insurmountable difficulties in the way of the proposed program.

The Council has defined itself in the following language:

"The Engineers' Council for Professional Development is a conference of engineering bodies organized to enhance the professional status of the engineer through the coöperative support of those national organizations directly representing the professional, technical, educational and legislative phases of an engineer's life."

And it has stated its objective as:

"The general objective of E. C. P. D. is the enhancement of the professional status of the engineer. To this end it aims to coordinate and promote efforts and aspirations directed toward higher professional standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social and economic problems."

This you will recognize as a rather ambitious and comprehensive program. Even the enthusiastic representatives on Council did

not believe any such tremendous objective immediately attainable and therefore an immediate objective of less comprehensive scope was adopted as a starting point. This is defined in the following words:

"An immediate objective, now apparently practicable of attainment, is the development of a system whereby the progress of the young engineer toward professional standing can be recognized by the public, by the profession, and by the man himself, through the development of technical and other qualifications which will enable him to meet minimum professional standards."

For the purpose of accomplishing this immediate objective the Council has four standing committees. These are:

Student Selection and Guidance
Chairman, Dean R. L. Sackett, College of Engineering, Pennsylvania State College

Engineering Schools
Chairman, Dr. Karl T. Compton, President of Massachusetts Institute of Technology

Professional Training
Chairman, General R. I. Rees, Asst. Vice-President of American Telephone and Telegraph Company

Professional Recognition
Chairman, Mr. C. N. Lauer, President of Philadelphia Gas Works

I might point out in passing that the character and caliber of these chairmen indicate not only the serious way in which the Council is going about its business but also the favorable reaction which its program has produced in busy men of national reputation. In fact, I have been very greatly impressed by the ready reception and approval of the program by all the representative individuals with whom I have discussed it. To me this indicates the movement to be timely and the program well considered.

Committee on Student Selection and Guidance

At the first annual meeting of Council last month this committee reported as its first objectives:

"1. To recommend sources of information for promising or interested high school or preparatory school students, their parents, teachers and counselors describing the qualities and aptitudes which contribute to the successful pursuit of an engineering education and the derivation of intellectual satisfaction therefrom; the quality and quantity of the major subjects pursued in college; the technical positions normally occupied by engineering graduates; the supervisory and executive positions into which they may

progress; the value of a technical education as a preparation for industrial and business pursuits and the activities and responsibilities of the professional engineer."

"2. If satisfactory occupational literature is not available, such material should be prepared, by revision or compilation, after consultation with the National Occupational Council and other sources of advice."

Very obviously this committee proposes to do what it can to feed proper material into our engineering schools. But I want to bring to your attention certain significant words in this statement of first objectives. I refer to the following:

"describing the qualities and aptitudes which contribute to the successful pursuit of an engineering education and the derivation of intellectual satisfaction therefrom" and this

"the value of a technical education as a preparation for industrial and business pursuits."

You will infer that the committee recognizes the fact that many students now take engineering courses as a preparation for non-engineering pursuits and also that the committee believes in such action and proposes to foster it. Both inferences are correct. While the Council was constituted to deal with the improvement of the engineer one of its important committees has discovered at the very start that it must take a somewhat broader view of its responsibilities. I am certain that you as teachers of engineering will have no quarrel with such a decision.

But, this committee has much broader activities in mind than those enumerated above. It is already studying

(*a*) Experience had in the field of occupational guidance,
(*b*) Camps, such as that operated by Stevens Institute, for pre-college students,
(*c*) Aptitude tests,
(*d*) Coördination and possibly coöperation with the National Occupational Council,
(*e*) Guidance lectures for high and preparatory school teachers,
(*f*) Coöperation with the Boy Scouts of America, and
(*g*) Coöperation with local organizations of engineers to the end that individual members may give guidance, encouragement and assistance to prospective students of engineering and the right kind of publicity to the engineering profession.

It is our hope that we may succeed in building up a practice similar to that which prevails in the medical profession with respect to recruits. You are all undoubtedly aware of the extent to which doctors of medicine go in assisting prospective medical students to get real inside views of the profession.

Committee on Engineering Schools

This committee has thus far devoted its major efforts to the study of accrediting of engineering schools and the formulation of a proper method of accrediting. The following excerpts from its report to Council at the annual meeting last month are highly significant.

"The committee has reached the conclusion that, although there is room for a considerable difference of opinion as to the theoretical desirability of accrediting, the facts are that accrediting of engineering schools is being done by several agencies and there is little, if any, coördination in these efforts. No thoroughly representative and authoritative body accredits engineering schools at the present time. The Engineers' Council for Professional Development is just such an organization and one of its proper functions should be to compose a list of institutions which, after careful investigation, are found to be adequately prepared to offer sound and comprehensive instruction in the various major curricula.

"Some method of accrediting engineering schools is required by force of laws governing the licensing of engineers in a majority of the states. In order that accrediting may be done uniformly, consistent with the high ideals of the engineering profession and in such a manner as to be a stimulus to the best development of engineering education, rather than a deterrent to future progress through codification of certain present standards, the National Engineering Societies should be invited to prepare and administer a plan of accrediting engineering schools. The following principles are suggested as the basis of such a plan:

"Absolute minimum standards of the education process have been avoided as likely to fetter future progress. Information on important aspects of organization, administration, curricula and standards of each school is to be assembled, the institution personally investigated by a committee and final action taken by the Engineers' Council for Professional Development after careful consideration of all aspects of the situation.

"Because of the variety of types of engineering training and the specialized character of many schools, accrediting is done on the basis of six major curricula rather than for the school as a whole. Allowance is made, however, for consideration of other curricula than these six.

"It is hoped that the accredited list to be prepared on these bases may be uniformly adopted, thus relieving societies and states from the necessity of duplicating individual action, and relieving schools from the necessity of submitting to numerous examinations and questionnaires.

"Inasmuch as there are movements under way at the present time in the direction of liberalizing the classroom requirements in certain engineering curricula, and for other reasons, it is not desirable to make any specification of the number of hours and credits which will be required in order that a curriculum may be approved. There should be no published prescriptions regarding curricula. A general statement of good practice with respect to hours, credits and so on should be distributed to the persons making visits for their confidential use."

In line with these thoughts the committee recommended definitely that Council undertake a program of accrediting the several curricula of the various schools of engineering which are deserving of such recognition and it presented a well developed and comprehensive plan for such work.

Let me emphasize the fact that whether we individually believe in it or not or whether we individually like it or not, accrediting of engineering schools is here, not through voluntary action of the profession, but through enactment of laws by state legislatures. It is surely far better and far saner to have such accrediting done on a national basis under the auspices of a body such as the Council which represents all parties in interest than to have as many different lists of accredited schools as there will be shortly if we allow Nature to take its course.

Committee on Professional Training

"This Committee on Professional Training has for its objective the preparation of a program which will combine the early experience of the young graduate engineer with a plan of study and further intellectual development until he is qualified for full professional status. This work bridges the gap between graduation, or its equivalent, and professional recognition."

I call your attention to the significance of the words "or its equivalent." The committee recognizes that at least for some time to come, there will be men entering the engineering profession through routes other than the formal schools of engineering and it realizes that the proper rounding out of such men is just as important as the treatment of college graduates.

This committee is well along on a program consisting of the following elements:

(*a*) Study of Junior Members or equivalent levels of constituent bodies of the Council for the purpose of determining numbers, names, locations, educational and occupational backgrounds, plan for self-development, etc.

(*b*) Preparation of a personal analysis blank which will assist an individual in making a program for his future development.

(*c*) Survey of educational facilities in areas of concentration of such men.

(*d*) Study of basic objectives for independent reading by such men.

Certain other elements have been outlined but are not yet carried beyond this stage.

In brief, it is the purpose of this committee to guide the young engineer in his further technical and non-technical education and in his economic and mental advancement.

Committee on Professional Recognition

This Committee has stated its purpose and policy in the following words.

The Charter of E. C. P. D. states:

"The Committee on Professional Recognition shall report to E. C. P. D. methods whereby those engineers who have met suitable standards may receive corresponding professional recognition.

"This Committee is concerned with the standards for entrance to the profession and the methods of establishing and maintaining them. If the profession is to improve the minimum professional and intellectual background of those servants of the public to be called engineers, it must itself establish high standards for those qualifications which will render the engineer a valuable member of Society. This involves emphasis on social, economic and general cultural training as well as the maintenance of high technical standards of education and practice.

"While such a procedure will also improve the status of the engineering profession in the eyes of those who use engineering services and in the view of other professions and the public, the primary purpose of all the activities of this Committee is and should be directed toward improving the services which the qualified engineer can and must render to the public.

"To guide the Committee in fulfilling its purpose, the following policy was adopted:

"The profession should establish as the goal of attainment, a series of qualifications for which the young man, whether graduate or non-graduate, may successfully strive continuously from the time he enters upon an engineering career. This goal of attainment, embodied in a certificate, equivalent to the professional degree and having a value recognizable as adequate to entitle the

holder to licensing or registration in a state, should be based upon the following features.

"*a.* Certification should be earned, and not granted as a mark of honor.

"*b.* The Code of educational qualifications should be more advanced than graduation from college, yet attainable by both college and non-college men.

"*c.* The attainments should be tested individually by examination (written and oral) or the equivalent and not gaged by personal estimates and testimonials alone.

"*d.* Educational qualifications should comprise scientific, technical, economic and civic knowledge of a mature order.

"*e.* The code of experience qualifications should normally make the age of certification fall between twenty-five and thirty."

It is hoped that by such means there may ultimately be brought about a general agreement as to a minimum definition of an engineer, that is agreement on minimum qualifications for recognition as an engineer. It is also hoped that when this is accomplished, the proof of the possession of such minimum qualifications shall entitle an individual to full recognition both in professional engineering societies and by state registration boards.

You will recognize the ambitions and program of Engineers' Council for Professional Development as very comprehensive and you will also recognize the fact that, if these things can be realized, the results will be of far reaching effect. I want to stress the fact that this Council is your creature since your organization is one of the seven sponsors and has its representatives thereon. I want also to bring forcibly to your attention the further fact that the Council has no authority to proceed on its own responsibility. It operates by recommending to its parent bodies and obtaining authorization to proceed with this or that plan or program.

Those things that I have told you about today are, therefore, plans which your organization and your six fellow organizations will ultimately be asked to pass upon and to authorize if in your good judgment they seem wise. I hope that, when they are passed up to you for such action, you will recognize that they are the work of earnest men who are giving whole-heartedly of their thought and their time to bring about a better condition in the profession for which you train men and in the world as a whole and I bespeak your consideration of such recommendations in the same broad minded spirit as that in which they have been prepared.

I cannot emphasize too strongly the fact that the E. C. P. D. is but a joint agency of seven bodies, of which you are one, which was

constituted in the hope, nay the conviction, that it could accomplish many desirable things which none of the sponsor bodies could accomplish alone. It works for and through these seven sponsors. And it can accomplish its purposes only if and as its sponsors give it the power so to do. That which it is intended to accomplish is admitted to be worth while, in fact necessary. Let us therefore remain united in our thoughts and in our efforts that we may get this job done handsomely. The world does not exactly expect it but it unconsciously awaits it.

INTELLECTUAL INTERCHANGE AMONG FACULTIES OF ENGINEERING SCHOOLS *

By DUGALD C. JACKSON

of the Massachusetts Institute of Technology

A man who becomes overtrammelled by rules, precedents, and tradition will always remain a commonplace man. One who breaks precedents and tradition seldom is a commonplace man and from such usually come the helpful leaders or notable criminals. The ones who break conventional rules with convincing service to fellow men and without injury to the social organism are the leaders. An instinctive ability to recognize the times and places when usual conventions ought to be observed, and when progress may be better achieved by breaking their shackles, is evidence of originality and vision. These qualities should be more fully cultivated in the faculties of engineering schools, and their evolution made a matter of our earnest mutual concern.

It is interesting to reflect on the erroneous conventions and traditions which came to us from the Victorian era and which have biased the thinking of the present generation. For example, it is still sometimes individually believed and taught (because of Victorian tradition) that the Periclean period in Athens was the golden age of the world. Nevertheless it probably was the orgy of exploitation and spending by Pericles and his party which brought ancient Athens to the brink of its downfall with resulting increase of sorrow and hardship for all of the population from the highest citizen to even the lowliest slave. Thinking of that period as a golden age for humanity, whatever its triumphs of sculpture and architecture, exhibits a failure to enquire and explore beneath a surface aspect which is deceptively polished and graceful. This deficient procedure is not appropriate to education which is to serve for the best interest of civilized society or its individual human components.

In our level of engineering education, and perhaps in all levels, teaching that is instruction without having associated with it the spirit of enquiry is bad pedagogy. That is, the practice of research is a vital part of engineering education. But research which is carried on in guarded chambers to avoid student contacts

* Presented at the 40th Anniversary Meeting, S. P. E. E., Chicago, Ill., June 16–20, 1933.

does not contribute to educational processes and may not be appropriate to engineering schools, although its discoveries ultimately may contribute to social welfare. Similarly, educational processes almost always become conventional and unvital if the processes are prevented from securing infusions of ideas from outside, whether this prevention is due to lack of enterprise or to intent.

Perhaps engineering education, being established in an expanding and interestingly changing field, may be less subject to devitalization and conventionality than education in some other fields of learning; but we all are aware nevertheless of the ease with which teaching can become conventional or even perfunctory. It particularly rests with those who work in the expanding and inspiring atmosphere of applied science to avoid conventional and uninspiring processes. Out of this concept springs another element in the importance of maintaining constant interrelations between all engineering school faculties and of making interchanges of studied views on educational problems.

The distinguished accomplishments of this Society (the Society for the Promotion of Engineering Education) through its Board of Investigation and Coördination and other committees, in expounding the trends of engineering practice, the processes of engineering education and the character of personnel appropriate to teaching staffs for the engineering schools, lay upon us who are in the teaching ranks a peculiar and exalted responsibility to make the most of opportunities that are thus shown to be within the reach of our hands. Reports of our situation and suggestions made for procedures are definitely before us. It is for us as individuals and as faculty groups to bring further fruit from the vineyard thus planted.

Professional distinction in the engineering field is supported on wise vision of the profession concerned, sound and independent judgment, and deeply rooted learning. This calls for talent, and it also calls for industry, energy, originality, and resourcefulness. The slavish follower after habit and tradition is sure to be left behind in this, as in any other, creative employment or profession.

Engineering is an affair of human welfare and those employed in engineering education must bear this in mind. Seekers after romance who "stand knee-deep in indolence" cannot rise to the high offices thrust upon a correctly chosen engineering teacher. Intellectual indolence is an irretrievable fault in any such. We conceive the life of the engineer as a high calling, and ask others to so conceive it, because (among other things) all those spiritually impelling activities which afford us means of distant transport of body or intelligence from place to place and from person to person are engineers' contributions to civilization.

The railroad, the steamship, the highway, the telegraph and the telephone provide statesmen with instrumentalities through which the substantial kinship of all the world some day may be established. Electric transmission of power and artificial lighting contribute substantially to ease and comfort in civilized life. Still fuller coöperation among applied scientists may yet become one of the wonders of the world and out of it arise benefits to mankind as yet undreamed. Even the health of individuals may become completely safeguarded by discoveries made possible by the joint application in the medical field of the learning of physiologists and the accurate instrumentalities for measurement which spring from the learning of engineers.

These illustrations point to the fact that further engineering achievements need not be assumed to be limited solely to improvements of existing instrumentalities utilized by society, but may be visualized as also including additional influential discoveries and inventions. With the development of civilization and its accompaniment of an organized society possessing protective agencies guided by the hand of a definitely established central authority, instrumentalities for communication between individuals and between communities take the place of instrumentalities of exclusion. Thus the building of walls to surround living places with intent to prevent enemy ingress but which also result in a decrease of mutual access between friends has ceased in the present era and the building of roads which increase access between peoples and contacts among the individuals has become widespread. Such great changes in living conditions (of which there are many), and equally great changes in the level of civilized thought, result in corresponding changes in the aims and the achievements of education.

The utilization of natural forces for the benefit of mankind has been the result of engineering originality and resourcefulness continued through the entire period of recorded history. The first such utilization presumably arose from crude observations of natural phenomena by some independent-minded person with curiosity and a love of economy, that is, an inventor, who was thus in a single embodiment the original scientist and the designer of the applications. Many ages afterward there came a period in which research in science became an end in itself, thereby bringing additional precious facts to the hands of engineers in addition to those which the engineers themselves had time to detect. Now we still farther develop this specialization between the so-called pure scientist and the engineer or applied scientist; and we also combine the two functions in coördinated fashion and in the hands of combination groups, for seeking out new facts and discovering new applications.

In order that mankind may be guided to use most desirably the great powers now at its command as the result of the applications of science, it is needful for engineers to inform themselves in the principles of political economy and psychology, in addition to the principles of chemistry, physics, and mathematics which are universally recognized as part of an engineering curriculum. These principles of political economy and psychology which are studied ought to be just as fundamental as the principles of the older sciences, but unhappily they have not yet been so formulated. Progress in this direction for political economy perhaps has been delayed by the fact that many of its teachers have sought the life of contemplative philosophers, while political economy is a dynamic entity associated with the changing social organization and therefore must be studied from the applied, experimental aspects.

Engineers carrying forward the front of applications of new discoveries are dealing with a growing field, full of changes, which cannot be mastered wholly through philosophical bookishness and contemplation. However, they are not fleeing from the past like the family of Lot from Sodom and Gomorrah. A backward review from time to time, of comprehensive but brief nature, produces good results in the way of evaluating progress and improving the accuracy of foresight, but we must also remember that too constant an eye on the past produces results which are as incurably useless as the pillar of salt in the alkaline desert into which Lot's wife was transmuted because of her backward longings.

Resourceful empiricism in life belongs to the days of the youth of the exact sciences or of education or of a new country with a pioneer population. We have these conditions all as a background for engineering education in America. In our present considerable maturity we must look forward to more rational bases of reflective life and of reasoning, but these must be secured without loss of national or personal originality, initiative and resourcefulness. Time is to-day, yesterday, and tomorrow. We have for ourselves only to-day, supported by some memories and records of yesterday and some anticipations for tomorrow. Therefore in our engineering education we must emphasize modes of life and knowledge of natural phenomena as they respectively exist to-day. We should also add thereto competent reflections concerning possible improved modes of future utilization of natural phenomena and probable improved conditions of life resulting from such improved utilization.

Science refuses to be enchained, but will continue with its victorious career of expansion. It is for the engineers to see that these victories are not merely Pyrrhic. For this, our educational

processes must touch, elbow to elbow, with the most intellectual expounders of principles that are established in political economy, sociology, and finance, in addition to our established association with expounders of the natural sciences.

Early histories deal at length with achievements of tyrants and warriors and but little with mechanical achievements. Such records show the emphasis which was formerly placed on the welfare of the high-born, powerful, and wealthy classes and their valuable slaves, to the substantial exclusion of all other orders of humanity. The shifting of this emphasis so as to rest, as it now mostly does in the western world, on community welfare, with the attention comparatively equally directed toward the high placed and the lowly, is one of the most conspicuous revolutions in social relations which has occurred between our days and the days of the ancient civilizations. The classicists are blind and misguided enthusiasts when they unreservedly extol the ancient civilizations. The cruelty and the narrowness of mental interest usually characterizing the powerful coteries in those civilizations is scarcely realizable to minds educated in the broader and more generous spirit of our times, although our times are often derogatively referred to as a mechanical age or civilization.

It is wrong to speak of a "mechanical" civilization, because civilization is intellectual and an intimate correlative or component of the social organization; but we must recognize that true civilization rests upon mechanical development which enables the spread of wealth and comfort to be effected immeasurably more uniformly than characterized the conditions of ancient times, such for example, as were characteristic of Greece or Rome or Egypt even in the most humane stages of their ancient civilizations. Science and invention can be put to bad uses, but this does not justify engineering education in neglecting the fullest practicable cultivation of the ground from which springs the best character of modern civilization, or in neglecting to examine the characteristics of that civilization itself.

Engineering is a vital and dynamic field of learning which stretches from biology, chemistry, physics, and mathematics into political economy, finance, and sociology. It is not practicable for any one man to possess complete mastery over the whole field or of any one of its major divisions. We therefore assign particular subdivisions to our individual teachers in the engineering schools, each of these subdivisions being of a scope in which the individual can achieve a mastery. This meets one branch of the teacher's difficulty, but further provision is requisite to meet the situation fully. Each particular subdivision closely relates more or less intimately with numerous other subdivisions as well as with

its own major division. Each major division relates with each other major division, sometimes with close analogies in the applicable theories, even when the nomenclature and units of measurement superficially appear to have no relations. And all the major divisions and the subdivisions have threads binding them to the natural sciences on one side and to political economy, finance, sociology, and psychology on the other side. Moreover, these threads are weighted with various degrees of significance, and this brings us face to face with situations which in some instances may be dealt with with mathematical exactness and in other instances can be dealt with only through examining the balance of evidence (*i.e.*, the balance of the "pros and cons" as commended by the great Franklin).

The problem of securing proper teaching staff for the engineering subjects taught in college therefore has two branches. One of these relates to securing men with the needed learning, ambition, originality, and resourcefulness to become and remain masters of their particular growing subjects, who also possess powers of formulation and exposition sufficient to establish scholarly interest in the study of their subjects. The second of the branches relates to selecting from among such men only those who individually have the imagination, ambition, and initiative to unremittingly examine and reflect upon the correlations with each other of at least some of the subdivisions of engineering and also upon the specific scientific and economic roots of some particular subdivision or subdivisions.

Any teacher who secures and maintains for himself mastery in a particular subdivision of engineering becomes an investigator on account of the nature of engineering, and such a one is competent for research into the character of scientific principles, their application for the benefit of man, and the propriety of empirical processes which may be utilized where science is not yet established because of the complexity of premises. Such a man is delivered from slavery to predigested textbooks.

It will be observed that the word mastery, as here used, is synonymous with the phrase: Authoritative grasp secured from fullness of knowledge and experience.

The major question to be answered is how such men are to be secured. Various answers have been proposed, but no one of them (in my opinion) is complete. I therefore venture here to give my own, and my doctrine is here spread before you with invitation for criticism and further test. In science, a theory which fails as a directive for further research within its province, or as a platform from which to improve designs of structures or equipment, is as worthless as the man whose wife called him "Theory" because he so seldom worked. The same is true of a theory in education.

The first tenet associated with my answer holds that experience proves that (in general) the engineering schools as a group must develop the teaching staffs for themselves and not expect to rely on other organizations, such for example as industries or schools of education, to develop our units for us; although we should welcome suitable reinforcements from such other organizations. The same conclusion is reached by *a priori* reasoning. This makes intellectual interchange among faculties very important. To secure what we need, each member of our staffs should strive to possess an education arising from experiences that have been secured by contacts with the cross-currents of various creative minds. Part of this should be secured in youthful preliminary education; but part of it ordinarily should be associated with the individual's early period of employment in teaching because the members of staff ought to become established before they are too old, as we need the activity of youthful originality and initiative in the engineering schools.

The second tenet is to avoid undue inbreeding. This requires an interpretation of the word "undue" to make the tenet definite. Different men of experience may ascribe different weights to it. In my opinion, inbreeding exceeding fifty per cent in staff membership may be undue. As a teaching staff grows in numbers and scholarly scope, it is desirable to seek promising recruits from elsewhere for the purpose of maintaining a flow inward of new experiences; but it is equally needful to maintain a continuous thread of endeavor, which can be most advantageously done by choosing a proportion of recruits from one's own products.

A corollary to the second tenet, therefore, is to select appointees from the product of other colleges as often as from one's own product, and to emphasize the fact that an advantage (especially for the younger staff members) arises from migration. The recognition of the latter condition should prevail over any desire on the part of an appointing officer to hold a staff inviolate from withdrawals. An engineering school has a duty in the preparation of young men for productive endeavor in other such institutions as well as for the industries and for itself. An undue jealousy of withdrawals of competent young men from staffs defeats this duty and also perhaps indicates a lack of fertility in selecting young men and encouraging them to make a high career.

The third tenet (which is closely connected with the foregoing corollary) is to encourage young men to study and observe in several environments. This may be through formal study elsewhere than at their normal sites of employment, or by suitable industrial employment for the period of a few years, or by organized study with which is associated industrial employment in

vacation periods. Industrial employment in the vacation periods in many instances is equally as serviceable for men of the older and well established ranks as it is for the younger men. The conferring of fellowships on younger members of staff, available for a year or two of serious study in a chosen academic setting elsewhere, is one of the fruitful expedients which is only too little recognized by engineering schools. Encouraging promising members of the staff to attend, in their individual fields, the summer sessions established for engineering teachers by this society, is a step in the same direction. If salaries and ambitions are right, young men should respond to this encouragement without special financial subvention, because response is farsighted thoughtfulness for personal development.

There is the further corollary that study and travel in European countries (for the American engineering teacher) have the advantage of unfolding widely different environments, and are likely to lead to sound reflection on the part of suitable young men. Individuals who have embraced such an opportunity and who fail to grasp the grounds for differences as well as for likenesses of engineering practice and engineering education on the two continents, along with some recognition of the faults of each, have been tested and found wanting and should thereupon be diverted from the profession of engineering education. As far as the facilities for engineering study themselves are concerned, America now rivals the best of Europe in substantially all branches and excels in many. Under the circumstances, the mature student who wishes to become a recognized influence in engineering education, who fails to uncover and embrace the opportunity to glimpse the ideals, the spirit, and the resourcefulness of several great men who are in his chosen field, in Europe or America, fails to fully utilize his opportunities for education.

The fourth tenet is to encourage teachers who wish to do summer school teaching to secure such employment in the summer-sessions of engineering schools distantly located from the sites of their own winter teaching. It is my opinion that continual teaching on the same premises and among the same colleagues during the academic years and the intervening summer-sessions inevitably cramps development. Staleness is likely to result from too continuous an effort of one kind carried on without external fertilization. It would be a step forward for the engineering schools to man every such summer-session with a considerable proportion of teachers drawn from other institutions.

Still another means for carrying through to the same fruitful end is for engineering schools to definitely exchange younger staff members for such periods as one or two academic years.

Difficulties for the engineering schools themselves arise regarding this on account of family movings, matching of living accommodations, differences of cost of living in different educational centers, differences of salaries in like ranks, and other items. This plan therefore is not likely to be frequently used, but all the other plans are practicable of execution, provided the necessary incentive is impressed on the individual teachers. This Society could achieve an additional forward step for engineering education if it undertook to procure the establishment of several definite exchange professorships among the American engineering schools, outside of the normal budgets of the schools, which could be conferred from year to year on particularly distinguished professors of such schools who would then lecture for a semester or two at schools other than their own.

The ideas presented herein are not academic platitudes, but are in fact pedagogical sense. They are paths of good business sense for engineering teachers to follow. To those who say that they are exalted but impracticable ideas, the answer is that they are indeed exalted ideas and engineering education needs such ideas put in practice as useful truths. Moreover, they are of proved practicability. For example, in the large staff of the distinguished department of electrical engineering of which I have the honor and privilege to be the leader, there are few of us who have failed to embrace education and practice in more than one richly serviceable environment. This circumstance has manifestly proved to the advantage of our mutual work.

Engineering education has been endowed with its fair share of great men. We may think of Swain, Van Hise, A. W. Smith, Irving Church, Mansfield Merriman, and others of their group. It now possesses a considerable proportion of such men and also of younger men with attributes that will bring them to equal eminence and influence; but President Wickenden in his final report as Director of Investigation for this Society expresses a fear that the number of such men is not increasing numerically in proportion with the growth of numbers of engineering schools and numbers of students. The work of each great man is a guide-beacon illuminating the way. But his successors who sit contentedly in the shadow of the beacon without effort to progress, waste opportunity. The doctrines of academic tenure for older men and academic freedom for both older and younger men are sometimes said to stand in the way of insisting on effective individual and group work. It is true that some individuals are unable to maintain their intellectual balance when partaking of the "strong wine of freedom," but such men are out of place in the teaching staff of an engineering school. It is a strain on the doctrine of academic

freedom to retain such men unless age, length of service, or laches of the institution appeal for tolerance.

Thinking with accuracy is no child's accomplishment. That accomplishment must be learned first in thinking analytically and then in thinking synthetically. Such education goes much faster when the effort is stimulated by the interest of mastery rather than when only sustained by the urge of duty. Each classroom and laboratory should be a space redolent with curiosity and discussion.

To secure the needed results it is important to utilize foresight and judgment applied through measures such as my answer comprises. All these measures depend upon developing among engineering schools a greater unity of purposefulness designed to result in a larger sentiment among their staffs in favor of migration than is now observable.

Finally, to secure the ends, in my opinion it is necessary for the engineering schools to maintain salaries in the higher levels which are equal to the highest which their universities support. Otherwise the ultimate attractions are insufficient to appeal to the fitting youths. I often hear it suggested that the upper available salary level has only small influence on the ambition of the younger teachers, but I am convinced that this is an erroneous interpretation of the attitude of the most able of our younger men. The opportunities of the life are compellingly attractive to men of suitable ambition, but the opportunities cannot be most fully developed unless finally accompanied by a generous situation in support of a professional self-respect that comports with a distinguished reputation for learned mastery in the field.

A sustained effort to accomplish these ends will, I believe, maintain engineering education on an enviable level of achievement among the great educational processes of the nation.

DISCUSSION

George C. Shaad (University of Kansas): In my years of experience in teaching, I have found two things which seem to be somewhat adverse to the profession. The first is that it is exceedingly easy to become conventional, or to get into a rut, or to grow stale, and we must be continually on our guard to prevent such actions.

The second is that the older we get the less are we open to changes of opinions, and to accept new ideas in our teaching work. This is especially true when we get to the point where we begin to talk about the "tenure of office" of the teaching profession.

It seems to me, then, that one of the best ways to keep alert (and we are told that the engineers must keep alert) is through

interchange of ideas: first, between teachers of the same subjects in the same institution; second, between teachers of different subjects in the same institution; then, better still, interchange of ideas with teachers in other institutions both in engineering and in other lines of education; and finally, the actual interchange of faculties among engineering schools, which is a subject for discussion at this time.

Our Society has done a great deal to facilitate the interchange of ideas among teachers of engineering both in the same institutions and in other institutions, but it has not done so much to promote interchange of ideas with teachers of other subjects or to promote the actual interchange of faculties.

However, I heartily believe in the interchange of faculties in so far as it is practicable, and along the lines which have been commented on by the author of the paper. I would, however, like to refer to one or two personal experiences which may perhaps have a little bearing on the subject.

When I started in the teaching profession, Professor Jackson arranged that I visit a sister institution for a period of two weeks, a type of interchange of faculties, if you please. I had absolutely no duties at the sister institution other than to attend classes, study their methods in curricula, visit the laboratories, and consult freely with the members of the staff. I wish to say that at no period of my teaching experience have I gained so much inspiration as I did in that brief two weeks spent at that institution. The institution was most gracious, and I learned a lot that was new, and I also learned that a good deal of the work that has been done at my institution was perhaps as good or better than that done by the other school. When I consider the inspiration and the material gained by such a brief visit, I can appreciate what might be gained by a complete summer session or semester or year in an exchange of professorship nature where one not only studied the methods but became a part of that second institution.

I also greatly believe in the members of the faculty going to other institutions for actual study and research rather than for direct teaching. I have long made a practice, in the case of young instructors, to limit tenure of office, if you please, to a period not to exceed two years, with the idea that if they do not expect to continue teaching they ought not teach for more than such a limited period; and if they expect to continue in teaching, then they should either follow the two-year period with graduate study, preferably at some other institution, or in gaining additional experience in another field.

O. J. Ferguson (University of Nebraska): Dr. Jackson gives us a glimpse of the ideal engineer. He is the dynamo which acts

between the field of biology, chemistry, physics and mathematics on the one hand, and that of economics, political science, sociology, and psychology upon the other.

And, I am persuaded that teaching is more a matter of inspiration than of instruction. He who would be a great teacher must be an inspirational force to his students, such a vital influence that the effect remains far beyond his days of contact.

There are men in this room,—you know them,—I know them,—whose presence and whose counsel inspire us all. We have been listening to their words for many years past, and through this Society's operation their class-rooms and those of their predecessors have been extended to the four quarters of the country. I assert with assurance that there exists no association of teachers of any classification which exerts a greater influence within its field than does this Society, in its own. Its record is a remarkable one. All honor to its founders!

But, the possibility of that record lies in the vision of the men within the Society. And that means that we have some great engineering teachers. How can we have more of them?

I agree with Dr. Jackson's first thesis—we must develop them ourselves. And I add to his interpretation of this tenet the thought that no engineering school is too small or too limited to be free from this duty. One of my most fundamental duties as an administrator is too try to fire my staff members with the zeal of their profession and to see that they have the opportunity to grow. Yes, if possible, to see that they outgrow their present positions, even if I lose them thereby.

His second tenet, "Avoid inbreeding."

This danger arises from the fact that we know our own students well and we feel safer in picking them; that we never feel assured that a newcomer to the ranks, from other schools, will meet our need.

By a judicious application of Dr. Jackson's third tenet, young men may achieve cosmopolitanism—by seeking experience and training in several different environments.

And the environments include more than geography—they compass types of work and character of associates.

The practice of many schools of considering an instructorship as terminating after a period of not over three years sometimes seems harsh, but it has its beneficial lasting effects in requiring early broadening experiences. It may be a kindness to a young man. If these required departures could be arranged upon an exchange basis, they might become more easily accommodated and therefore better promote the condition we are discussing.

As I presumed would be the case, Dr. Jackson emphasizes the

research aspects of educational work. And I know that he does this without in the slightest degree belittling our schools where limitations of funds and of time set serious restrictions upon our programs.

Probably the greatest inspiration to our instructors who are serving elsewhere may come from their research activities, the challenge of unexplored fields, and their contact with giants of research. May I point out another aspect—a practice that can have helpful effects?

There is possible research in teaching methods which is just as vital as research in engineering practice or physical science. These studies too are open to the smaller schools and faculties as well as to the larger ones. They may be undertaken in small department groups. And, here, a newcomer, an exchange instructor can be a very great force in challenging existing methods, proposing new viewpoints, new objectives, new emphases. Around the departmental table many a lively discussion is experienced, and many an idea is worked out clearly enough to be brought to fruition in the class room and the laboratory. If you have exchange instructors, don't neglect this opportunity for mutual good, the regular departmental discussion of best practices.

J. W. Barker (Columbia University): An excellent engineering teacher is more than an engineer and more than a pedagogue, he must be both, mixed with a salad dressing of scholarly research, personality and interest in young men. Such men are not produced by taking brilliant students and putting them through the grades of assistant, instructor, assistant professor, etc., on a survival of the fittest basis. An inspiring teacher is the product of a cross-breeding process which carefully fertilizes him with the pollen falling from our most brilliant senior teachers of not only engineering but of the natural sciences, of the social sciences and of pedagogy.

Rightfully we rail against crass empiricism in our engineering methods but haven't we been indulging in exactly that method in our attempts to secure engineering educators. Dr. Jackson has again exhibited his careful analytical mind and his broad vision in placing before us his four tenets for producing good engineering teachers. As a former member of his department staff I have discussed them with him innumerable times and with all of them I am in hearty agreement. There is, however, one more tenet I venture to suggest adding to his four, although it might be considered a corollary to his third tenet.

Dr. Jackson insists that as a group we must develop the teaching staffs for ourselves not depending on industries or schools of education to develop our units for us. Right indeed but just as

he later in his third principle advises industrial work so would I like to emphasize the acquisition of sound pedagogical methods. Our Summer Schools for Engineering Teachers have been noteworthy examples of this and we can learn much from the professional teachers of teaching methods.

I think each of us would valiantly maintain that there are some things our school does better than any other school does them. No school, no matter how distinguished, has a monopoly on good methods. No teacher worth his salt but is constantly endeavoring to make his presentation of his subject the very best. No one method, however, will suffice for each truly inspiring teacher varies his presentation to fit the particular class at his feet. These are but additional arguments to support Dr. Jackson's propositions.

Training our own younger teachers doesn't mean putting them into a rut, it implies a broadening, a cross-fertilization, a deepening of scholarly knowledge, a widening of mental horizons, a catholicity of interest accompanied by a growing mastery of a particular field of endeavor. Certainly inbreeding of a department or school works in the narrowing rather than broadening direction. Reasonable migration of graduate students and junior staff from school to school, from school to industry and from industry to school is a healthy sign if not caused by an inadequate salary scale or by choked promotion on a seniority basis.

I am particularly in favor of the travelling fellowship for junior staff. Only too frequently we choose our fellows from our own students and then limit them to studying with us. Many fellowships are restricted by the terms of the gift or statute establishing them to study at that particular institution but not so many have restrictions as to whom they may be granted. Perhaps here is a place where some one of the Committees of this S. P. E. E. might function by bringing together a summation of the various fellowships available at all of our schools and giving publicity to the terms of each.

The exchange of younger staff members for one or two academic years would be particularly helpful in rounding out and increasing the scope of such junior professors. Where institutions have sabbatical leaves surely such can be most properly utilized to assist in overcoming the very real practical difficulties of which Dr. Jackson speaks so correctly.

We must treat this whole problem of interchange in a courageous, forward-looking, broad-gauged fashion if we are to stimulate the production of good inspiring engineering teachers. The success of our schools of engineering, the growth of our industries and the progress of our civilization depend on our ability to train

the younger staff members to an ever increasing productivity as teachers. Not only must we train engineers to take their place in the world of industry but we must train our successors as teachers. Haphazardness and empiricism in this latter process must be replaced by a purposeful, courageous, broad vision.

Douglas Anderson (Tulane University): When I noted in the program for the discussion of Dr. Jackson's paper the geographical distribution of the men selected to open the discussion, I felt that the effort was being made to secure the point of view of institutions from as widely separated portions of the country as possible.

In my discussion, therefore, I shall feel warranted in considering certain phases of the subject from the point of view of conditions in my own particular portion of the South, which is one of the jumping off places (and we must remember, of course, that the South covers a very large section of this country), perhaps even from the more restricted viewpoint of my own institution, a comparatively small engineering college in a large, privately endowed university, free from political or sectarian control. If you lived in the South, you would realize that this last expression has quite a meaning.

No one, of course, would even question the statement that "the practice of research is a vital part of engineering education." And yet I feel that much very excellent teaching can be, and is, done in the true spirit of research under conditions where the extensive equipment and mechanism required for many of the problems of modern engineering research may not always be available. Those of us who may be connected with institutions where such extensive facilities are not available must be frank enough and honest enough to recognize our limitations, and in the direction of the work of our really able students to advise them where to find their best opportunities for research. Much excellent material and assistance toward this end may be found in the reports of the Committee on Engineering Research of this Society.

Dr. Jackson has placed before us, so to speak, very complete and very interesting plans and specifications for the ideal engineering teacher of the present and the future.

The answer to the question, how are such men to be secured, has been given so fully in the paper that there appears little left to be said except by way of comment.

Dr. Jackson's first tenet that the engineering schools as a group must develop the teaching staffs for themselves appeals very particularly to me. As you see, I have assumed the point that Dean Barker just made, that Dr. Jackson was considering the development of teachers by the engineering schools themselves as a group rather than each individual school. I question whether our engi-

neering schools are sufficiently aggressive in the matter of encouraging their graduates to adopt teaching as a profession. In my own experience in the past, when young engineering graduates could secure good jobs at high salaries, it was difficult to interest any of them in teaching on account of the small financial return in comparison with positions in the industrial fields. That situation, however, has undergone a rather complete change, and, as the correspondence that now comes to the desk of any dean or department head of an engineering school will testify, there has developed a much keener appreciation of the advantages of the teaching profession.

I am particularly averse to placing too much reliance upon schools or departments of education for the training of teachers of engineering. There is ample evidence throughout this country, perhaps more particularly in the South and in the state institutions, that the schools of education in our universities are making strenuous efforts to *control* the standards and qualifications for the appointment of university teachers.

Quite a large group of men in my own institution feel that this is a situation fraught with the possibility of such serious consequences that they are making an earnest effort to combat the apparently growing demand, on the part of the schools of education, that every university teacher, no matter what may be his subject, must have devoted a very considerable portion of his time to such subjects as the history of education, teacher training, etc.

The summer schools for engineering teachers, under the direction of our own Society, would certainly offer a most valuable medium for young teachers of engineering to receive helpful and valuable "contacts with the cross-currents of various creative minds," quoting Dr. Jackson's own very expressive statement.

Up to the present time inbreeding has never been a serious problem in my own college of engineering, partly for the reason previously alluded to that, with few exceptions, our graduates have been much more interested in securing positions in the industries than in the field of teaching. Nevertheless, while we have not had to contend very much with the question of inbreeding, we still feel that our younger men should, if possible, be sent away in order to secure a wider field of training, with the result, therefore, that for the last ten or fifteen years the recruitment to our teaching staff has been almost entirely from other institutions. With an average enrollment of 325 students and with 30 teachers of professorial rank, only 5 of them are graduates of our own institution, and 2 of these 5 have pursued their advanced studies at other places.

This small degree of inbreeding with us is also the expression of a definite belief that for an institution such as ours, where the

opportunities for research in engineering are not as extensive as they might be, our best men who are looking to teaching as their life work should be encouraged to go elsewhere for their graduate study.

The younger members of the teaching staff should certainly be encouraged in every way to take advantage of the opportunities which arise from a reasonable degree of migration, as well as from industrial employment during the vacation periods.

Not one of the least obstacles to this sort of migration is that these young teachers are human beings, like the rest of us, and just so soon as their remuneration reaches that critical but delectable point at which two may live as cheaply as one, they go off and get married. And even in these advanced days of mechanical devices for taking care of the drudgery of housekeeping, of efficiency apartments, etc., a young man with a wife may not be shifted about and disposed of so readily as if he were single. When such problems arise the dean may perhaps feel a high degree of sympathy with the original plans of Thomas Jefferson for the University of Virginia, in which all the dons were to be bachelors and live in quarters adjacent to those of the students. But it did not work even there.

It does not seem to me that the obstacles to carrying out the suggestions in Dr. Jackson's fourth tenet with reference to an interchange of the younger staff members between colleges are so great as to preclude a considerable amount of experimentation along this line.

Take, for instance, two institutions with about equal numbers of men on their teaching staffs with equal facilities in the matter of equipment, and with similar salary scales, and it would appear that the interchange might be made with considerable facility. Especially would this be true of the unmarried teachers. An investigation of all the details of the problem might show that it would be possible for the two parties even to exchange living quarters for the session in question, thus reducing to a minimum the cost of moving. It would certainly be of interest to this Society, and in line with Dr. Jackson's suggestion, if several groups of similar colleges would appoint committees to investigate and report upon the possibility of the project.

Due, principally, perhaps, to the fact that the standard engineering course in this country is a four-year undergraduate one, we still fail to emphasize sufficiently the status of the college of engineering as a professional school. Especially is this true where the engineering school is a part of a large university. Dr. Jackson's last point is that engineering schools should maintain salaries

which are equal in the higher levels to the highest which their universities support.

There is a tradition in this country that the salaries of law professors should be greater than those in the arts colleges and in the engineering colleges, and it is a fact that, as a general rule, they are higher, certainly in the South. This is a condition which, in my opinion, can and should be corrected.

If you will pardon another personal reference, I would like to tell this little story of what happened at Tulane. This was a condition some years ago in Tulane University when the law school professors were paid considerably higher salaries than the engineering professors. We bore patiently with the great inequality in salaries as between the lawyer and the engineer for a long time, until at a certain critical period in its development it became necessary to effect almost a complete reorganization of the college of law.

New men and good men were then brought into the college of law on a scale of salaries higher than before. This was the straw that broke the back of the engineers' camel. We made emphatic representations. We won the sympathy and the support of the president and through him the favorable consideration of the board of administrators, with the result that salary levels in the two schools are now equal. Perhaps our next step will be for the lawyers and the engineers to combine and go after the medical men, because they still enjoy higher salaries.

A careful and sympathetic investigation on the part of individual institutions of the problems here discussed and a continued spirit of coöperation so ably supported through the activities of this Society will, in my opinion, do much to bring about the adoption of the admirable principles set forth in Dr. Jackson's paper.

Vice-President Rogers (Oregon State College): I shall confine my remarks more particularly to a few comments upon pertinent points rather than a discourse upon the philosophy which Dr. Jackson has so admirably presented in his paper, a philosophy which presents to us our common heritage and our common responsibility in the engineering science and technology of this age.

There are a few specific things which I should like to mention that I think are timely and pertinent.

I agree with Dean Anderson that there is a growing conviction upon the part of educationists that their discovery of the methods of pedagogy is one of the most important things in higher education, and I have known them to be so audacious as to declare that with the knowledge of pedagogical methods they are better qualified to instruct in engineering fields than those who are prepared

by a knowledge of subject matter. Such a position is indeed ludicrous.

Personally, I believe very firmly that in our lower division work we have particular need for a thorough understanding of the science of pedagogy, of educational psychology, of special methods, and that the measure of that particular need and service rendered and given in that lower division is to be found in the performance of the students in the upper division under conditions that allow the professors to devote their major interest and attention to the fields of subject matter.

Another point upon which we frequently hold discussion is that concerning the relative value of work in the practical fields, and advance work in our educational institutions. There are some who hold that it is much more desirable for a young graduate to secure work in practice, and others who hold that it is perhaps equally desirable for him to secure work in research and at the graduate level. It is rather difficult to generalize upon these two viewpoints. In some fields, I believe one is true; in others, the second is true. I do feel, however, that perhaps the mastery of that type of subject matter which can be most profitably presented in our engineering schools can be secured quite adequately in our graduate courses under the proper supervision and direction. I hope some day we may come to a position in the administration of our engineering schools when we will recognize that certain proportions of our budgets must be set aside for development. That, I believe, might be anywhere from five to ten per cent of the current teaching budget, and such sums should be devoted toward the advancement of the staff members, whether it be in fields afar or in our own immediate laboratories, or whether it be in the fields of engineering practice.

I don't entirely subscribe to the statement of President Wickenden to the effect that there is a very disturbing disproportionate ratio of promising young men being recruited into our engineering staffs as compared with the increase in enrollments and schools.

I do feel, however, that under our present system of tutelage all of our young men grow up with the impression that fate and their neighbors will take care of them. It seems to me that one of the lessons of this depression which all of us have had to learn is that the fates and our neighbors are not taking care of us. It is not surprising that young men hold that viewpoint. The responsibility for a change in that viewpoint lies with school administrations, and I believe we need a fuller realization of that responsibility on the part of the engineering administrators.

We are too prone to confine ourselves to the mechanics of administering, to focus our attention upon executive direction and

managerial control, those things which I would put on the left hand in administration. In contradistinction to this, however, I believe our greatest responsibilities lie in the field of leadership and supervision, and I believe any administrative officer can find various ways and means whereby the young men under his direction will move rapidly forward into mastery of their respective fields of engineering and in scientific interest. Certainly, in a faithful administration no dean should fear the outgrowing of a young man in a position on his staff. If one develops so rapidly that a school is unable to hold him, that contribution to the general field of engineering should be made with pleasure and satisfaction.

The possibility of exchange of staff members between institutions has been extensively discussed. I don't think there has been much discussion of the possibility of coöperative work within our staffs. Certainly, in the lower division, where an understanding of pedagogical method is most essential and where tradition perhaps prevents a department head or a dean from visiting classrooms too frequently, there is a great opportunity for developing a cooperative spirit in which staff members will themselves take the initiative in visiting the classes of their colleagues. Much is to be learned by wholesome coöperation of this nature, and I know from my own experience that such coöperation can be stimulated to the satisfaction of the administration and the staff members themselves.

I agree with Dr. Jackson that the obstacles of academic freedom and academic tenure do not exist when we have upon our staffs the right kind of men. Those who are worthy to teach should be so stimulated by their interest that regardless of the clock or their vacation periods they will pursue with vigor and enthusiasm the subjects which are their responsibility. I know it is very possible to convert an ardent golfer into an ardent research enthusiast. I know that it is possible to find the lights burning in your laboratories at all hours of the night, and to even meet men on the street at eight o'clock in the morning going home to get their breakfasts after a night's work. Now, I don't mean that all faculty members will do that, but I have seen some faculty members do so.

I believe the Society has a responsibility in promoting the development of engineering teachers. How that responsibility can be discharged is open to question: Certainly by the interchange of information concerning opportunities; certainly by a cataloging of facilities that may be available.

The report which Colonel Rees gave, on the work of the subcommittee on professional training, suggests the possibility of directing the attention of our younger staff members to personality blanks, through which they would be assisted in analyzing their par-

ticular aptitudes and interests, and outlining a program of development and study with that assistance. I believe we may take a leaf from the proceedings of that committee in a short time that can be appropriately applied to our own work.

I believe it is most hopeful that we to-day have discussed the philosophical aspects of our common heritage and our common responsibility, and I trust that in the near future we will find administrators interchanging among themselves descriptions of the opportunities which are available at their respective institutions, and approaching each other with the idea that young faculty members may be interchanged.

WHAT CAN WE DO TO AID THE STUDENT AFFECTED BY THE DEPRESSION? *

By EDWARD C. ELLIOTT, *President*,

Purdue University

I

As we, with the rest of the world, pass from the familiar epoch that was, into the strangeness of the era that is to be, we find ourselves surrounded by a fog of uncertainties and indecisions. The very foundations of the professional house, in which we have lived and worked these many years, with more or less comfort, and with a firm confidence as to its stability, seem to be shaking and shifting. There is a feeling, vague for some, vivid for others, that years ahead are to contain new adventures, and will demand the exploration and pioneering of new regions.

Yet, however clearly we try to see the way before us and however scientifically we play the part of prophets, we may not be wholly unlike Columbus whose career as a discoverer was recently humorously interpreted thus: Columbus didn't know where he was going; when he arrived he didn't know where he was; and when he returned he could not tell where he had been. We may not now know definitely where we are going. We may not know exactly where we are when we get there. We may be assured though that we are not to have any chance of coming back. We are on our way at the present moment—to a somewhere different from the here we know.

In the ordering of the particular subject assigned to me, "What Can We Do to Aid the Student Affected by the Depression," I have tried to include something more than a consideration of those familiar first aid remedies for the individuals suffering from or inconvenienced by a lack of the customary economic resources. The need is not for poultices to be applied to poverty. Rather the profession of engineering must employ a prophylaxis reaching far beneath the surface of things.

II

While the world is in its present state of disequilibrium there is above all a prime responsibility of maintaining for ourselves and

** An abstract of an address delivered at the Conference of Administrative Officers of Engineering Colleges, University of Wisconsin, July 4, 1933.*

our students that sense of self-responsibility and that quality of self-confidence called *morale*. That great school man of the last generation, G. Stanley Hall, described this as superhygiene.

> "The hardest of all the hard things man does in this world is to look a very new and complex situation that is pressing and important squarely in the face, comprehend all of its elements, assign each its due weight, and then respond with the right attitude, behavior or decision . . . is the essence and acme of morale."

III

The long-range *morale* here in mind, will impel more cold-blooded frankness toward the student intending to prepare for an engineering career. This will involve critical analysis of the individual's intellectual equipment, his material resources, and what is of yet more importance, his capacity for accepting chances in what may be a chanceless world. One must have admiration for that student who, when recently told that only about ten per cent of his class would have any immediate opportunity for professional employment, replied promptly, "Well, I intend to be one of that ten per cent."

IV

A code of new professional honesty in dealing with students requires that we also be professionally honest with ourselves. Six years ago, I expressed myself upon the phase of this as follows:

> "The greatest struggle going on in the world today—significant and for the most part carried on in silence—is the struggle for the possession of superior human ability. Those who have the capacity to see beneath the surface of things have become keenly aware of the efforts on the part of groups and classes to secure for their own purpose the relatively few of human kind possessing capacity for extraordinary achievement. It does not require any high quality of prophecy to assert that in the next generation, and in the generations to follow, that nation, that class, that group which in this generation succeeds in winning the larger share of individuals of superior ability and training will control the affairs of our civilization."

It goes without saying that in the past decade the engineering professions have been a lure for tens of thousands of the ambitious youth of the land. How long will that lure continue to be effective?

In the recent past the quantity of raw human material available to us was so large that we could rigorously search out the best, and ruthlessly discard the rest. The resulting human scrap heap accumulated outside of the walls of our engineering schools may no longer be regarded as merely the product of the inevitable law of selection. Just as readily may it be considered to be a measure of institutional wastefulness.

In the existing emergency there has been placed upon engineering institutions the clear responsibility of correlating their output with the capacity of society to utilize that output. The charge that education is the only undertaking that goes on manufacturing without any reference to marketing conditions ought not to be valid against those institutions devoted to the selection, training and education of engineers. After all, may it not be expected that the underlying principle of engineering science—the discovery and utilization of the power of nature—be applied to the power of human nature.

V

The times dictate new efficiencies in dealing with students as students. What is taught, how it is taught, how much is taught, and who does the teaching, are old questions that are to receive new answers. At no other points can more aid be given to students than here. You will not classify me as a mere idol smasher if I venture the firm conviction that the curse of engineering instruction is to be found in the bulk of the substance of the great majority of technical courses. The capable student conquers his assignments. Necessity compels the student of moderate, and even more, ability to qualify as an expert in superficiality. I hazard the prediction that we shall soon begin the all-important project of drawing new distinctions between the professionally relevant and the professionally irrelevant.

VI

It goes as a matter of course that every institution will exercise itself to eliminate or to reduce to a minimum all non-essential and marginal expenses of the student. The cost of living in the community or on the campus, the payment of fees under a partial payment plan, the cost of textbooks and other supplies, the expense of honorary student organizations and of extra-curricular activities, continuing unabated from the days of prosperous spending, chiefly because of recognized face-saving powers, these and other items are self evident opportunities for institutional service for the economic salvation of students.

VII

There are other ways of being practically helpful to the unemployed graduate. The best of these may be encouraged—and sometimes assisted—toward graduate study. Others may be assigned to scientific "busy" work projects. Here again is a major problem of professional morale. The experienced, capable, unemployed alumni represent one of the stark tragedies of the day. The

students of the past must be included with the students of the present if we are to have any comprehensive aid plan to reduce the destruction of the depression.

VIII

Finally, we have an unescapable responsibility to review the cardinal American doctrine of the equality of educational opportunity and to reassess this doctrine for the purposes of conserving the fundamental values of engineering education. Taking a wholly disinterested view of the things to-day one is justified in having fear of the development of a new American cult of dependence. American higher and professional education has come to its present state because along with our principle of social opportunity has gone the principle of personal, responsible independence. Even with its debatable points, I like the recent statement of President Hutchins of the University of Chicago:

> "Pursuing the student in America calls for more than the records of his daily movements; it includes a large amount of nursing. Universities have developed the idea in parents, or parents have developed it in universities that the institution is in some way responsible for the moral, social, physical and intellectual (shall we say also occupational, E.C.E.) welfare of the student. This is very nice for the parents; it is hard on the universities, for besides being expensive, it deflects them from their main task, which is the advancement of knowledge. . . . But sooner or later the university must take the position that the student should not be sent to the university unless he is independent and intelligent enough to go there."

IX

In our desire to help students during the present direful state of things, it should not be forgotten that the institutions we represent are stewards of the profession of engineering. That profession, to perform the new and gigantic tasks that lie ahead, must be recruited with young men, who during the period of training have come to recognize the essential nature of standing, unaided, on their own feet.

Postscript

Since the Madison gathering I have had occasion to express in another form one of the central ideas of July. One paragraph seems to be pertinent to the discussion:

> "Arguments pro and con, especially con, as to the real worth of University training have come to be among the educational by-products of these days of our disillusionment. This is what might be expected.

Thousands upon thousands of men and women trained in our higher institutions, and possessing master navigators' licenses for the seven times seventy seas of American opportunity find themselves left high on a barren beach by the high tide of prosperity. Whose fault? No doubt if a complete assessment were possible the responsibility would be shared by society, by the institutions and above all by the individuals themselves. The critical questions to be answered—if there is to be a new weal—are such as these: What kind of individuals should be given higher training? What should that training be? How shall the responsibility for education be divided between the institution and the individual? We have not yet fixed this latter share. Whenever a person claims that his university failed him in that he wasn't allowed to develop his own individuality or initiative, it is almost certain that close examination will disclose not the liability of the institution but some easily recognized lack on the part of the individual. Nevertheless this represents an unsolved human problem to which our organized education must consciously devote itself in the immediate future.''

THE STATE AND ENGINEERING EDUCATION*

By HARLAN H. HORNER,

Assistant Commissioner for Higher Education, the University of the State of New York

Throughout its history the University of the State of New York, which under the State Constitution is the official "head" of the State Education Department, has been responsible under organic law for the administration of higher and professional education in the State and for the licensing of candidates for practice in the several professions. Since 1920 the profession of engineering has by statute come under such regulation. The regulation of engineering was justified by the State in this language appearing in the statute (Education Law, Section 1450):

> "In order to safeguard life, health and property, any person practicing or offering to practice professional engineering or land surveying in this state shall hereafter be required to submit evidence that he or she is qualified so to practice and shall be licensed as hereinafter pro vided."

In the actual language of the statute the practice of professional engineering is defined as follows (Education Law, Section 1449, paragraph 6):

> "A person practices professional engineering, within the meaning and intent of this article, who holds himself out as able to perform, or who does perform any professional service such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects, wherein the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of engineering principles and data."

Before dealing in detail with the administrative and professional problems which confront the State Education Department in the enforcement of the engineering statute it seems desirable to comment briefly upon the relation which has existed in the State between the professions of architecture and of engineering. The practice of architecture was first regulated by statute under the Regents in 1915 or five years earlier than that of engineering. Here again the State justified its regulation of the profession in this language (Education Law, Section 1476, paragraph 1):

* An address delivered at the Conference of Administrative Officers of Engineering Colleges, University of Wisconsin, July 7, 1933.

"In order to safeguard life, health and property, no person shall practice architecture in this state, or use the title architect or any title, sign, card or device to indicate that such person is practicing architecture or is an architect, unless such person shall have secured from the regents a license as architect, in the manner hereinafter provided, and shall thereafter comply with the provisions of this article."

The statute defines the practice of architecture as follows (Education Law, Section 1475, paragraph 6):

"A person practices architecture within the meaning and intent of this article, who holds himself out as able to perform or who does perform any professional service such as consultation, investigation, evaluation, planning, design, including æsthetic and structural design, or responsible supervision of construction, in connection with any private or public buildings, structures or projects, or the equipment or utilities thereof, or the accessories thereto, wherein the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of the art and science of construction based upon the principles of mathematics, æsthetics and the physical sciences."

It is one thing to record in statutes nice definitions of the practice of architecture and of engineering. It is quite another thing to regulate the practice of the two professions within the indefinable "no-man's-land" where architecture and engineering merge. For fifteen years architects and engineers in New York State developed bad blood and called one another names because the State was endeavoring to do the impossible by statute, that is, to make the practice of architecture and of engineering mutually exclusive. Two years ago, under the initiative of the State Education Department and with the cordial coöperation of the State Boards of Examiners in architecture and engineering, the two professions buried the hatchet and joined in urging legislation, enacted in the session of 1932, which it is now firmly believed will make for permanent peace. Briefly, this happy situation was reached by amending the statutes so as to put architecture and engineering substantially on a par as learned professions as regards required preliminary and professional education, practical experience, licensing regulations, privileges, penalties and detailed supervision by the State.

Agreement was finally reached by the provision in each statute that every applicant for a license as a professional engineer and as an architect shall be required, in addition to all other requirements, "to establish by written examination his competency to plan, structurally design and supervise the construction of buildings and similar structures."

It was further provided in the statutes that nothing in the regulation of one profession should restrict or interfere in any way with the practice of the other profession. As the situation stands

today, apparently cheerfully accepted by the two professions throughout the State, a licensed professional engineer may practice freely what is defined as the practice of architecture in the architectural statute but he may not style himself an architect unless he qualifies so to do under the law. In like manner, a licensed architect may practice what is defined as professional engineering in the engineering statute but may not style himself as a professional engineer unless he qualifies so to do under the law. In other words, the State now frankly acknowledges the indisputable fact that completely mutually exclusive definitions of the practice of architecture and of professional engineering are impossible and seeks to safeguard life, health and property in the high parallel levels of the requirements for admission to the two professions. The architect may practice professional engineering if he finds opportunity to do so; the professional engineer may practice architecture if he finds opportunity to do so. The public may choose either the licensed architect or the licensed professional engineer for any work it wants in either professional field and is assured by the State that in any event it will find a trained man duly authorized to undertake its work.

It is confidently believed in New York State that mutual relationship between architects and professional engineers will in no sense destroy the independence and solidarity of the two professions; that the public will still turn unhesitatingly to the man it deems best fitted to perform the task it wishes undertaken whether he is licensed as architect or as professional engineer; and that neither licensed architects nor professional engineers will undertake responsible assignments for which they do not deem themselves personally fitted. In any event, the scheme is established by law with the whole-hearted endorsement of the two professions and the State expects that licensed architects and professional engineers as well as the public will contribute their full share in the safeguarding of life, health and property in the enforcement of the two statutes.

Under the law as it stands at present for license as a professional engineer evidence must be submitted that the applicant (Education Law, Section 1452):

1. Is more than twenty-five years of age;
2. Is a citizen of the United States or has legally declared his intention of becoming a citizen;
3. Is of good moral character;
4. Has satisfactorily completed an approved four-year high school course or the equivalent thereof as determined by the Department;

5. Has had eight years or more of practical experience in professional engineering work of a grade and character satisfactory to the Board;
6. Has passed the prescribed examinations.

The Department, on the recommendation of the Board of Examiners, may waive specific qualification requirements, except as to age, character and citizenship, in the cases of applicants who are possessed of long established and recognized standing in the engineering profession and who have practiced lawfully for more than twelve years. The Board may also exempt from examination, except in structural design, a graduate of a college or school of engineering registered by the Department as maintaining satisfactory standards. Under this latter provision of the statute, the Department has hitherto registered one hundred and fourteen schools and colleges of engineering in the United States and Canada as maintaining satisfactory standards.

After January first, nineteen hundred thirty-seven, with the exception of persons presenting evidence of at least twelve years of practical experience in professional engineering of a grade and character satisfactory to the Board, every applicant for a license as professional engineer will be required to submit evidence that he has graduated from a school or college of engineering registered by the Department. This means that admission to the practice of professional engineering in the State of New York will, after January 1, 1937, be predicated upon the completion of a satisfactory college course in engineering. It is expected that by the time announced the great majority of the candidates for licenses will be graduates of schools or colleges of engineering.

It will be readily understood, therefore, that the State Education Department is profoundly interested in engineering education, not only in the colleges within the State but in the colleges throughout the country. While the Constitution and the organic Education Law, as well as the several professional statutes, give the State Education Department a large measure of authority over all phases of higher and professional education, deliberate effort is made by the Department to avoid giving directions to or making demands upon the colleges, universities and professional schools within the State. Effort is made to work out all procedures and to formulate such rules and regulations as are necessary in cooperation with higher educational authorities. In the light of the amendments to the engineering statute which have been mentioned as well as in the light of widespread disturbed educational and economic conditions generally, the Education Department has been making a special study in coöperation with the engineering schools and colleges, of engineering education, not merely as related to

professional licensure, but as regards the scope, content and objective of all courses on the college and university level. It seems desirable to record the results of a series of conferences and committee meetings which have been under way for the last two years.

On April 2, 1932, a conference of representatives of schools and colleges of engineering within the State was held at the Education Department at Albany. Each of the thirteen institutions in the State in which engineering courses are offered was represented. It was the first time in history for all the educational agencies in engineering to come together to consider problems of mutual interest. The degrees in engineering being conferred by the several institutions, the scope, content and length of courses in academic years and in semester hours, the function and objective of the licensing examination in professional engineering and its relation to and dependence upon the work of the schools and colleges, were discussed at length. No immediate changes in any procedures or rules were proposed. At the conclusion of its deliberations the conference voted unanimously to recommend to the Commissioner of Education the appointment of a committee of five deans of engineering colleges to study in detail the problems discussed at the conference and to offer its recommendations as regards future procedure before a second conference of all the engineering institutions in the State.

Accordingly the Commissioner of Education appointed the following committee:

Dean J. W. Barker, School of Engineering, Columbia University, Chairman;

Dean Dexter S. Kimball, College of Engineering, Cornell University;

Dean Collins P. Bliss, College of Engineering, New York University;

Dean Louis Mitchell, College of Applied Science, Syracuse University;

Dean E. J. Streubel, Polytechnic Institute of Brooklyn.

The committee met at the Education Department on May 16, 1932, and addressed its inquiries to three broad series of questions: (1) degrees in engineering courses; (2) courses of study in engineering; (3) professional licensing examinations in engineering. The committee prepared a report of its deliberations together with its recommendations which was transmitted to all the schools and colleges of engineering on June 2, 1932. The committee proposed that ample time be given for the consideration of its report before a second conference should be held to consider it, the feeling being strongly held by the committee that its proposals should have mature deliberation and that no effort should be made to establish

any common ground of future procedure except with the consent and approval of all the institutions involved.

Several months were thereafter given to informal exchange of views upon the issues involved and the Education Department, in the meantime, invited all the schools and colleges of engineering to submit constructive criticisms of the scope and content of the licensing examination in professional engineering as set by the State Board of Examiners.

A second conference of representatives of all the schools and colleges of engineering in the State was held at Columbia University on May 12, 1933. This conference was attended also by the entire Board of Examiners in Engineering. The substance of the report of the committee of deans and the recorded judgment of the conference will perhaps be worth presenting here under the general headings, degrees, courses of study, and licensing examinations.

Degrees

The Committee employed civil engineering as a type, because courses in that field are given in twelve of the thirteen institutions in the State in which any engineering courses are offered. At the completion of the customary four-year course in civil engineering it was found that degrees are conferred as follows:

In *two* institutions, Bachelor of Science (B.S.),
In *two* institutions, Civil Engineer (C.E.),
In *five* institutions, Bachelor of Science in Civil Engineering (B.S. in C.E.),
In *two* institutions, Bachelor of Science in Engineering (B.S. in Eng.),
In *one* institution, Bachelor of Civil Engineering (B.C.E.).

It was found that eight institutions confer a second or master's degree in civil engineering as follows:

In *one* institution, Master of Science (M.S.),
In *three* institutions, Civil Engineer (C.E.),
In *one* institution, Master of Science in Civil Engineering (M.S. in C.E.),
In *three* institutions, Master of Civil Engineering (M.C.E.).

It was found also that the so-called professional degree of Civil Engineer (C.E.) is being conferred by five institutions. Thus it appeared in the field of civil engineering that twelve institutions confer *five* different degrees as a first or bachelor's degree, eight institutions confer *four* different degrees as a second or master's degree and five institutions confer the so-called professional degree of Civil Engineer (C.E.). The greatest confusion appeared in the use of the C.E. degree. It is conferred by ten institutions as follows:

As a bachelor's degree by *two,*
As a master's degree by *three,*
As a professional degree by *five.*

The committee found a like confusion in chemical, electrical and mechanical engineering. It was the unanimous judgment of the committee that simplification of the existing degree situation is desirable and possible and that engineering education has progressed in recognition as a distinctive professional faculty to the point where degrees granted upon the recommendation of an Engineering Faculty should bear the title "Engineering" rather than "Science." Many combinations of degrees were considered. The committee attached no more significance or value to one combination than to another, but simply endeavored to advance a proposal that might be generally acceptable. Length of the course of study in years was not felt to be an adequate basis for common action in the conferring of degrees, whereas the length of time spent on purely professional study was regarded as a more reasonable basis of agreement. The pre-professional requirement was agreed upon as meaning substantially the completion of Mathematics through Integral Calculus, Physics, Chemistry and Mechanics.

The committee, therefore, submitted for the consideration of the conference, the following proposal for degrees in engineering to be employed in the future by the schools and colleges of engineering in the State of New York.

It was voted unanimously at the general meeting on May 12, 1933, that the conference of deans go on record that the list of degrees proposed by the committee is a reasonable objective toward which New York State schools of engineering should work and that the registration of new schools of engineering by the Department should be dependent thereon. The Polytechnic Institute of Brooklyn already employs the degrees recommended by the committee and the Rensselaer Polytechnic Institute has recently announced the adoption of the plan for all students hereafter admitted. Several other institutions have indicated a willingness to adopt the plan. All interests agree that no compulsion should be put upon any institution or upon any faculty to adopt the degrees proposed. The Education Department is engaged in a comprehensive study of degrees conferred in all fields by all the higher educational institutions in the State. If, as now seems likely, the engineering schools and colleges of the State adopt the suggested degree scheme, the Regents of the University of the State of New York will be requested to modify their list of authorized degrees to conform to the common basis acceptable to the schools and colleges of engineering in the State. It is not expected that the complete adoption of such a degree scheme in the State will in any way

*Fields of Engineering	Degrees Earned in Course				Professional Degree	Honorary Degree
	Bachelor's Degree. At least one year beyond completion of the preprofessional requirement	Bachelor's Degree. At least two years beyond completion of the preprofessional requirement	Master's Degree. At least three years beyond completion of the preprofessional requirement	Doctor's Degree. At least five years beyond completion of the preprofessional requirement	At least three years after bachelor's degree is earned	When institution is authorized by charter to confer such a degree
Chemical	B.S. or A.B.	B.Ch.E.	M.Ch.E.	D.Ch.E. or Ph.D.	Ch.E.	D.Eng. or Sc.D.
Civil	B.S. or A.B.	B.C.E.	M.C.E.	D.C.E. or Ph.D.	C.E.	D.Eng. or Sc.D.
Electrical	B.S. or A.B.	B.E.E.	M.E.E.	D.E.E. or Ph.D.	E.E.	D.Eng. or Sc.D.
Mechanical	B.S. or A.B.	B.M.E.	M.M.E.	D.M.E. or Ph.D.	M.E.	D.Eng. or Sc.D.
Mining	B.S. or A.B.	B.E.M.	M.E.M.	D.E.M. or Ph.D.	E.M.	D.Eng. or Sc.D.

* Any other recognized field of engineering to follow like nomenclature.

effect the Department's registration of approved schools of engineering outside of the State, where, as is well known, even greater confusion exists in the granting of engineering degrees.

Courses of Study

The committee gave consideration to the Regulations of the Commissioner of Education dealing with the registration by the Department of courses of study in schools of engineering. These regulations read as follows (Handbook 36, University of the State of New York, 1932):

> A school of engineering to be registered must meet the following requirements:
>
> 1. It shall have adequate equipment and resources.
>
> 2. Provision must be made for satisfactory practical summer field or shop work or the equivalent in course and there shall be adequate facilities for such practical work either within the institution or by satisfactory arrangement with industrial establishments.
>
> 3. It shall have an adequate technical library and shall make adequate annual appropriation for the maintenance thereof.
>
> 4. It shall have a sufficient number of full-time salaried instructors giving their entire time to instruction but in no case less than eight. A majority of its technical faculty and all instructors of professorial rank shall have received engineering or scientific degrees.
>
> 5. A satisfactory graded course of four full years shall be maintained, each year to be at least 34 weeks in duration. Not less than 50 per cent of the course of study shall be devoted to purely technical courses and the remainder to courses of cultural value including at least one year of English.
>
> 6. The admission requirement shall be the completion of a satisfactory four-year high school course of study (15 units) or the equivalent as determined by the Commissioner.
>
> 7. Candidates for graduation shall have completed the full four-year course in engineering.

It was the unanimous judgment of the committee that it would be undesirable for the Education Department to elaborate its regulations governing the registration of courses of study in schools of engineering, but that it might be desirable for the Department, after exercising its usual procedure, to consult with representatives of recognized engineering institutions in the State before taking final action upon applications for registration.

The attention of the committee was called by the Department to the average distribution of the courses in civil engineering in eleven colleges in the State with the query as to whether or not any fixed number of semester hours should be set for graduation. The distribution of the courses in civil engineering in eleven colleges appeared as follows:

English	9.8 hours
Foreign Language	3.0 hours
Mathematics	17.3 hours
Natural sciences	22.8 hours
Social sciences	5.7 hours
Miscellaneous academic subjects, including physical training	20.9 hours
Total non-technical courses	79.5 hours
Total technical engineering courses	70.0 hours
Average semester hours for 11 schools	149.5 hours

The range of the semester hours required in the eleven institutions in New York State is from 129 to 181.

The committee was unanimous in its judgment that the Department ought not to fix any definite number of hours as the minimum requirement for the completion of a satisfactory course in engineering but was of the opinion that such a course should ordinarily include from 140 to 150 semester hours.

The conference held on May 12, 1933, recorded its unanimous approval of the suggestions and recommendations of the committee touching courses of study, namely:

1. That the Department should not fix a rigid semester hour requirement for graduation from an approved school of engineering, but that a satisfactory course should ordinarily be expected to cover from 140 to 150 semester hours.

2. That it is undesirable for the Department to amplify or to elaborate its regulations governing the registration of an engineering school.

3. That it is highly desirable for the Department to consult with the representatives of established schools of the State before registering additional schools of engineering.

Licensing Examinations

The conference on May 12, 1933 endorsed unreservedly the view of the committee that degrees and courses of study in engineering should be considered apart from strictly administrative problems arising in the Department in the licensing of professional engineers. Indeed, the conference concurred unanimously in the judgment of the committee that the Department should exercise great care not to permit licensing examinations to impose standards in courses or in methods of teaching upon the schools and colleges. The Board of Examiners, participating in the discussion of the licensing examinations at the conference, recognized that a new approach to the examinations will become necessary as more and more of the candidates for licenses come before the Board with college degrees. It is expected that the Board will not attempt to repeat examinations in subject matter upon which

the candidate has satisfied the requirements of his college for graduation. Beyond such fields of examination as are specifically required by statute, it is expected that the Board will confine its tests to the discovery of the ability of the candidate as a practical engineer rather than to the range of his scholarship. The conference was happily in full agreement that the close coöperation between Department and Examiners, on the one hand, and schools and colleges on the other, is at all times highly desirable.

Such, as briefly as it has been possible to present it, is the situation at present in the field of engineering education in the State of New York from the standpoint of the State Education Department. Of even more importance to the Department than what degrees are to conferred, what the formal length and content of courses shall be and what the range and scope of the licensing examination shall be, is the broader question of what actually and finally constitutes a satisfactory course in engineering. We look forward to January 1, 1937, when every applicant for a license as a professional engineer "shall submit evidence that he has graduated from a college or school of engineering registered by the Department as maintaining satisfactory standards." That provision of the engineering statute gives the Department just as much concern about the professional standing of schools and colleges of engineering throughout the country as about those within the State. Due to the presence of the City of Greater New York in the State, which constantly allures professional men from all parts of the world, in the course of every four or five years the Department is called upon to evaluate credentials from every college in the United States, as well as from all quarters of the globe.

All of the New York State professional statutes enjoin the Department not to admit to professional licensure any candidate from another State or from any foreign country upon requirements less than those prescribed by statute or upon educational standards inferior to those maintained by approved institutions within the State. The statutes admonish Department officials not to discriminate against New York State educational institutions; frank, honest performance admonishes such officials also not to discriminate in favor of home institutions.

Facing enforcement of the new requirements of the engineering statute, therefore, the Department is equally concerned about the professional standing of the hundred or more schools and colleges of engineering throughout the country and the dozen such institutions within the borders of the State of New York.

All schools and colleges of engineering hitherto registered by the Department desiring to be continued on the approved list have been requested to file applications for re-registration. The Depart-

ment will issue no list of approved institutions in 1933 and expects to give an entire year to the determination of its new list. Agreeing fully with the deans of the schools in the State that elaborate and unduly specific criteria for the measurement of the worth and accomplishment of an engineering school are not desirable, the Department is nevertheless acutely conscious of the need of some more dependable basis than it has been hitherto able to devise for determining what schools shall be placed upon its approved list. Experience has shown that it is a comparatively simple matter for any college worthy of the name to satisfy with documentary evidence the customary regulations governing equipment, resources, shop work, field work, technical library, number and qualifications of staff, length, content and organization of the course of study and specific requirements for admission and graduation.

If the Department is to be content with conformance to a set of arbitrary regulations, then it might just as well make up a comprehensive list of the schools and colleges of engineering of the United States and Canada, so designating themselves, and let every applicant with a degree become a candidate for a professional license. The Department believes, however, that biological laws apply to engineering schools as well as to individual human beings. Not all schools may be expected under present conditions to reach a satisfactory minimum level and certainly there is a wide gap between the best and the poorest.

How is the Department to determine that performance equals declaration, that results spring from the promises of a college catalog and that the possessor of a college degree in engineering is the trained man, contemplated by the statute, worthy of being entrusted with the "safe guarding of life, health and property" in the field of professional engineering within the State. Frankly, the Department confesses its sense of inadequacy as it faces the problem of evaluating the engineering schools of the country. It wishes not to be bound strictly by rules and regulations, yard sticks and pigeon holes. It wishes somehow to give true evaluation to the character and quality of the teaching, to the integrity and intelligence of the research and to the discriminating common sense of the administration, which lie back of the announced purposes and accomplishments of any reputable school of engineering and which after all determine its genuine standing.

Facing an exceedingly difficult task, a bit uncertain of the criteria that ought to be employed, certain that material standards are not sufficient to measure intangible accomplishments, the Department is looking forward with great interest to the results of the studies of the S. P. E. E. and its allied agencies upon the ques-

tion of accrediting engineering schools and colleges. The list which the Department hopes to issue in June, 1934, will, according to present indications, be a shorter list than the one now in force. It will be established without discrimination. Every institution finding place upon it will meet the material standards which it is relatively easy to attain and likewise will satisfy the intangible requirements which cannot be measured in ordinary ways. In determining what the bases are for evaluating the intangibles, the Department expects to rely heavily upon the zeal and devotion of the Society for the Promotion of Engineering Education and upon the continued highly prized and helpful coöperation of the deans and faculties of engineering colleges within the State. When the list is established, the Department hopes and confidently expects that it will command the respect of the engineering profession of America.

THE RELATIONSHIP OF GENERAL AND ANALYTICAL CHEMISTRY COURSES TO THE TEACHING OF METALLURGY *

By ERIC R. JETTE,

Associate Professor of Metallurgy, Columbia University

It is generally recognized that metallurgy, particularly process metallurgy, is applied inorganic chemistry. Further, almost all metallurgical operations involve analytical chemistry in the control of the process, the composition of the charges, or the evaluation of the product. Thus we may safely say that most metallurgists have considerable use for whatever knowledge of inorganic and analytical chemistry they may possess. Exceptions to this statement undoubtedly exist, but the fact that some graduates rapidly get into rolling mill, administrative, or other work requiring virtually no knowledge of chemistry has not changed the general requirements in chemical training for metallurgical engineers.

Few students in undergraduate years have any idea of what their future work in the fields of their major studies will be, and their teachers realize the hazards of attempting to make predictions on this important matter. Teachers and administrators of colleges and technical schools probably accept it as their duty to give each student, through the broadest possible training, a background of fact and theory which will enable him to meet his individual situations with reasonable assurance. The constant revamping of metallurgical curricula and individual courses indicates that complete satisfaction has not yet been attained. In the specific case of the chemical training of metallurgists it is evident that there is still much to be done.

A study of the curricula of thirty schools giving degrees in metallurgy or metallurgical options in mining or chemical engineering shows that the chemical training generally consists of two semesters or quarters of general inorganic chemistry, one semester or quarter of qualitative analysis and one semester or quarter of quantitative analysis. In no case were more than two semesters of general inorganic chemistry required and a considerable number of schools require only one semester. In several institutions where only one term of inorganic chemistry is required, there are

* An address delivered at the Mining and Metallurgical Session of the Summer School for Engineering Teachers, University of Wisconsin, July 20, 1933.

increased requirements in quantitative analysis. Only two curricula contained more than one term of qualitative analysis.

All the standard textbooks in inorganic chemistry today have much in common. The pedagogical results of the various courses depend primarily upon the amount of teaching time devoted to the subject and to a lesser but none the less important extent upon the textbook chosen, the personal views of the teacher, the facilities for lecture demonstration and laboratory work and the personal interest of the student. Obviously, there is little of a general nature which can be summarized concisely about this part of the metallurgist's training. At this point it will only be observed that in view of the pronounced chemical nature of metallurgical work, one semester of general inorganic chemistry seems to the writer to be a *very* narrow foundation.

As regards qualitative analysis, there seem to be three types of courses with, naturally, almost every conceivable intermediary. On the one extreme, we find qualitative analysis used as laboratory work to illustrate the chemical properties of metallic elements. In nearly all inorganic or general chemistry textbooks, the metallic elements are discussed in the later half or third of the text and hence in this type of course laboratory work in qualitative analysis is virtually the laboratory work for the second term of the inorganic chemistry course. In such a course the theory and technique of qualitative analysis are likely to receive rather scanty attention.

In the second type of course, qualitative analysis is treated as an excellent opportunity to teach the physical chemistry of dilute solutions, using the practical analytical operations of the laboratory more for the purpose of illustrating these principles than for anything else. In this type of course the analytical operations must be carried out with such care that comparatively few analyses are made. None of the reactions which the metallurgist needs most are included.

The third type of course considers qualitative analysis as the best opportunity in the chemistry curriculum to give the student a first-hand and intimate knowledge of a wide variety of chemical reactions. Characteristic of this type of course is the large number of substances analyzed, unknowns being given to the student both in solution and in the solid state. The theoretical side, which means the application of the solubility product principle, the ionization constant, hydrogen ion concentration, etc., is not given as much attention as some persons would like. Courses of this type are criticized by instructors of both the other types, by the one group as requiring too much time and by the other group as being too "sloppy."

In quantitative analysis we find a considerably greater variation in the time spent than in either inorganic or qualitative analysis. The usual curriculum involves one semester, generally it is one lecture and 6 hours of laboratory. In other institutions they may require as high as three semesters with from 6 to 9 hours of laboratory each semester, and one or two lectures. In some institutions the work is given in the metallurgy division; in some it includes fuel and gas analyses. A great deal of variation may be expected in the content of the course in quantitative analysis in the various institutions. Much depends, for example, on how much attention is paid to the calibration of instruments, weights, burettes, etc. Much depends also upon the type of material given for analysis, the accuracy demanded, and upon whether the student is trained to make precise analyses or routine analyses. Only in a few places does the work in quantitative analysis seem to be of strictly metallurgical character.

This, then, is the general situation with respect to straightforward chemical training of metallurgy students. The individual courses are naturally apt to be widely different in different institutions. The actual amount of work done in two hours lectures and six hours laboratory in one institution may be nearly as much as is accomplished in three lectures and 9 hours laboratory in another institution. It depends largely upon the organization of the course, the character of the student, the teaching ability of the instructor, and the laboratory facilities available. Strict comparison on the basis of points, credit hours or class and laboratory schedules is therefore quite impossible.

We may now inquire as to what a metallurgist needs in the way of straight forward chemical training. Opinions on this will, of course, differ and I can only offer my personal viewpoint.

An extensive knowledge of quantitative analysis is not, in my opinion, the ultimate goal of chemical training for metallurgy. I am not sure that quantitative analysis is anything but a minor and incidental objective in this training. Again, I am expressing a personal opinion when I say that the main objective of chemistry courses for metallurgists is general chemical experience. This term perhaps needs clarification. General chemical experience to me means a broad knowledge of the properties and reactions of chemical compounds, a knowledge which has been attained not only through reading and lectures but of even greater importance, through laboratory experiments. In its best and most satisfactory form it is the result of direct first-hand experience which, in turn, means experience gained in the laboratory. The average student is entirely too prone to accept literally the statements in his textbooks. He fails to appreciate the implications, the if's and but's

which belong with almost every "statement of fact" in the texts. He generally fails to see that his chemistry books deal almost exclusively with pure substances and that in actual experience pure substances are rare. It is essential for him to get experience not only with pure substances but with mixtures of substances. He must be trained to consider the various components of mixtures, to anticipate their mutual effects and to carry out his experiments with due regard for these factors. Laboratory experience is practically the only way to fix such matters in the student's mind. It is particularly important for metallurgists to get this kind of experience. The metallurgist deals with the raw materials of nature or with materials prepared from such natural substances by methods purposely designed not to give chemically pure materials. For such cases, textbook statements may not be expected to apply without proper interpretation and modification.

It is obvious that the training for general chemical experience begins with general inorganic chemistry. However, the advisability of introducing at this point much discussion of the mutual influence of various substances in mixtures upon each other, is extremely doubtful. If the student is made acquainted with the more important topics of inorganic chemistry and if, in his laboratory work, he learns the main reactions of the various elements and their compounds, this is all we may expect. To learn these topics and to acquire the range of laboratory experience which is needed as groundwork for general chemical experience requires at least two terms of lecture and laboratory work if it is to be done adequately. Emphasis is to be laid on the fact that this general chemical experience necessitates from the very start first-hand laboratory acquaintance with many different reactions.

In qualitative analysis many of the reactions of pure substances may be repeated, but here for the first time the student is called upon to deal with mixtures and involved sequences of operations. The course in qualitative analysis is the ideal place for extending the student's knowledge of inorganic chemistry as training for general chemical experience. The advantages are numerous. This is the only point in the curriculum where the student is apt to use the same reactions often enough to become really familiar with them. This is his first opportunity to get himself out of difficulties in which he finds himself due to his own mistakes or purposely introduced into the work by his instructor. He can compare the behavior of various elements or compounds, by themselves and in mixtures. Here is an opportunity for dealing with solid substances alone and in mixtures. Here for the first time he has put up to him the problem of getting substances into solution, and he gets acquainted with the behavior of concentrated acids and alkalis,

fusions, etc. All this is possible, of course, only if qualitative analysis is taught with this purpose in mind. If this subject is taught as an incidental part of general chemistry or an introduction to the physical chemistry of aqueous solutions, most or perhaps all of this will be missed. Possibly one of the most important reasons for extending the work in qualitative analysis is that this course is easily modified to the particular needs of metallurgists. In any case, two terms of this subject are needed by metallurgy students and in at least one of them, substances such as ores, slags, and alloys which are of direct metallurgical interest should be introduced as unknowns.

I wish to emphasize that there is a quantity factor in this training for general chemical experience. Not only must the student be given a high quality of training by means of proper organization, proper selection of topics and experiments, and close check on his working habits and his observations, but there must also be provided the opportunity for him to use at least the commoner types of reactions frequently.

I realize very well that the work in qualitative analysis must be completed by the end of the second year if the usual sequence of courses is to be maintained. I realize even better, the difficulty which faces everyone who makes out a curriculum, of getting all the subjects into those two years which the faculty insists must go there, and in this connection, the stern limitations set by the number of hours per day and the student's capacity for work. Nevertheless, I feel very strongly that more extensive training in inorganic chemistry is necessary for the modern metallurgist, and therefore propose as an alternative that an additional course in advanced inorganic chemistry be given to metallurgists, perhaps in the last year. In such a course, I should include (1) a discussion of the relative properties of elements and compounds, especially the metallic elements and their compounds, on the basis of the periodic system; (2) a thorough treatment of oxidation and reduction, including the meaning and use of e.m.f. data and a general interpretation of electron transfer in ionic reactions; (3) a thorough discussion of equilibrium in its qualitative aspects; (4) a general discussion of some of the more complex inorganic compounds, complex ions, Werner coördination theory and coordination number, amphoteric oxides and hydroxides, etc.; (5) a discussion in its qualitative aspects of the structures of atoms and molecules, the meanings of electron transfer and electron sharing; the difference between an ionic compound and a "metallic" or non-ionic compound, the nature of solid solutions and why the law of definite proportions apparently is of so little use in many substances of metallurgical interest, etc.; (6) some special

topics of industrial inorganic chemistry, such as the lead chamber and contact processes for making sulfuric acid, the burning of lime, the manufacture of cement, the manufacture of and uses of sulfur dioxide, the preparation of some of the more important inorganic pigments, the manufacture of coal gas and water gas, etc.; (7) finally, no course in metallurgy is complete without a critical discussion of the chemistry of metallurgical reactions. The last is the most important topic on the list.

I am sure we can all agree that future progress in process metallurgy will be facilitated greatly by a critical analysis of our present processes. In such an analysis, the chemistry of the various processes is the first matter to be considered. The technical side, of course, cannot be neglected, but the technical apparatus is designed to carry out certain chemical reactions. Any *fundamental* change in the apparatus demands a better understanding of what that apparatus is to do. Such an analysis will naturally involve the application of physical chemistry as well as inorganic, but at the present time I shall deal only with the latter.

I have been advocating more extensive training in inorganic chemistry for metallurgists, using the term inorganic chemistry to include qualitative and quantitative analysis. The thought will naturally arise in the minds of many metallurgists and teachers that the metallurgy curriculum already contains too much material. Many, perhaps, believe that we teach the chemistry that metallurgists need to know in our courses in process metallurgy. I agree that the curriculum is too intense. I disagree emphatically that the metallurgy student learns in metallurgy courses the kind of chemistry he needs to know. In fact, I would go even farther and state that from the chemical point of view, metallurgy courses are wretchedly done.

Statements of this sort, of course, demand justification, and I should say at once that I do not claim to be acquainted with the details of process metallurgy courses throughout the country. It is to be supposed, however, that standard textbooks represent with some degree of fidelity the *fundamentals* of the subjects as they are taught today, especially if the texts have been written fairly recently. It is upon the study of five standard texts, four of them written since 1925, that my opinion is based.

In each case I have examined the chemical equations under the topics of roasting, copper, lead, zinc, gold and silver simply from the standpoint of what they mean in terms of our ordinary conceptions of chemical equations. In the following table the results are classified for each text under two headings, the total number of equations given, avoiding the duplicates as much as possible, and the number of equations which were distinctly doubt-

ful as to validity, genuinely misleading, and wrong. In this study such minor matters as equations which failed to balance and equations for solid-solid reactions that have no medium in which to take place, were not listed in the doubtful, misleading and wrong group.

TABLE OF EQUATIONS

Textbook	Total Number	Doubtful, Misleading or Wrong	
		Number	%
A	108	33	31
B	90	36	40
C	95	30	32
D	66	23	35
E	63	17	27

In view of the fact that these are textbooks on metallurgy written for metallurgy students by authorities in metallurgy, this record is anything but satisfactory, especially since it is also to be observed that some writers give scarcely any chemical equations in the discussion of such important subjects, from the chemical standpoint, as the hydrometallurgy of copper or the metallurgy, both pyro and hydro, of zinc. One would imply from such a study either (1) that the writers had not given the chemistry of the processes sufficient critical thought, or (2) that the chemistry of these processes is on the whole very incompletely known. For most metals, the latter is certainly true, but this is scarcely a valid excuse for such a large percentage of errors.*

Implications as serious as these cannot be dropped without giving specific examples. Before giving examples, however, it will be advisable to make sure that you understand what a chemical equation means to me. We may take the hypothetical reaction

$$4AX_2 + 4BY + 5Y_2 = 4BX + 2A_2Y_3 + 4XY_2.$$

In the first place, the formula for each substance must be correct. In the second place, when four mols of AX_2 are used up by this reaction, four mols of BY are used up simultaneously and, among the other substances, four mols of XY_2 are produced. In other words, if we state that a certain amount of any one of these substances has been used, the corresponding stoichiometric amounts of each of the other substances has been consumed or produced. These, of course, are fundamental principles, but they are disre-

* Some authors more or less consistently and others occasionally, guardedly preface an equation by stating that "this is supposed to be" or "probably is" the equation.

garded in the equations for a number of metallurgical reactions.

As examples, we may take some equations copied directly from one or more of the above texts. As an example of a wrong formula, we have

$$Fe_2SO_6 + 2C = 2FeO + 2CO + SO_2.$$

I have not the slightest notion of what the first compound is but the equation is formally correctly balanced. Another case is

$$CuO + (NH_4)_2\ CO_3 = CuCO_3 \cdot 2NH_3 + H_2O.$$

The only formula I know for complex cupric ammonia compounds existing in aqueous solution contains $4NH_3$ for each Cu.

As examples of reactions in which the stoichiometric relations demanded by the equation would occur only by accident, we have

$$2Fe_2O_3 + 8CO = 7CO_2 + C + 4Fe,$$
$$NaAu\ (CN)_2 + 2NaCn + Zn + H_2O = Na_2Zn\ (CN)_4 + Au + H + NaOH.$$

In the first case, the substances in the system can react in several different ways simultaneously, and the situation is further complicated by the fact that there are also several series of consecutive reactions possible between Fe_2O_3 and CO. The production of carbon is the result of a side reaction and the ratio of one atom of carbon to seven molecules of CO_2 is entirely misleading. The second example is clearly two simultaneous reactions taking place at independent rates, viz:

$$2NaAu\ (CN)_2 + Zn = Na_2Zn\ (CN)_4 + 2Au,$$
$$Zn + 4NaCn + 2H_2O = Na_2Zn\ (CN)_4 + H_2 + 2NaOH.$$

The ratio of one gram of hydrogen to 197 grams of gold, if ever found, would be entirely fortuitous.

Formulas for the elements also seem to give opportunities for curious equations. When one sees

$$As_2 + O_3 = As_2O_3$$

one wonders if the author really meant diatomic arsenic reacting with ozone. Confusion rather increases when the above example is followed by

$$PbS + PbSO_4 = Pb_2 + 2SO_2,$$
$$Cu_2S + 2Cu_2O = Cu_6 + SO_2.$$

In a somewhat different category of mistakes, we occasionally find equations for reactions which at least appear to be thermody-

namically impossible, such as

$$3SO_2 = 2SO_3 + S,$$
$$4HgS + 4CaO = 4Hg + 3CaS + CaSO_4.$$

The first can actually be shown to be impossible; the second is queer, especially the ratio of 3CaS to $1CaSO_4$, no matter how you look at it.

Another type of equation which has no sense is shown by

$$4PbS + 4Fe = 3Pb + PbS + 3FeS + Fe.$$

If the author intended to indicate that the reaction was incomplete, this would seem to be the worst way of doing it.

Equations for chemical reactions should convey another kind of information which to me is frequently of greater importance than the stoichiometric relations. Practically all metallurgical reactions are heterogenous. For this type of reaction, it is possible to write equations which are both stoichiometrically and thermodynamically correct and yet, from the kinetic standpoint, the reactions would be practically impossible or at best exceedingly slow. It is my contention that if the equations for chemical reactions are to be of any real help in the understanding of metallurgical, and other processes as well, they must be so written that they give some idea of *where* in the system the reaction can take place. This, of course, implies that the mechanism of the reaction is known, and for metallurgical reactions, this is rarely the case. It is true, however, that mere inspection of many of the metallurgical equations shows that the reactions which they represent are kinetically highly improbable. I refer particularly to the equations indicating that two or more solids react to produce a set of products, although we are by no means limited to this particular type of reaction.

It is a fundamental principle that if two molecules are to react with each other, they must be brought into contact. In the case of solid-solid reactions, the only places where different molecular species can come into contact are those points at which the different solids touch. It will be seen immediately that we can secure reaction-resulting contacts when only two solids are involved, even though the contact area is necessarily small, but if three molecular species are involved, in order to produce a reaction, the required contact between the three different solids is exceedingly improbable. In this connection it is to be observed that while at the most the contact between two phases is an area, the contact between three phases is a line. Yet, apparently such reactions frequently do take place at appreciable rates. This, of course, means only that the reaction actually takes place in some other way which does not involve this kind of contact.

Before proceeding further with this development, it should be observed that we can divide solid-solid reactions into two groups. In the first, we have those reactions in which the contact between the solid phase is increased in strength and area as the reaction proceeds. A reaction of this sort, for example, would be that between a metallic oxide and silica to form a silicate. In this case the reaction product forms an intermediate layer and the subsequent interaction takes place by diffusion through this layer. If the product is liquid at the temperature concerned, the problem becomes essentially one of rates of solution and thus drops out of our present classification.

The second group contains those reactions in which the accidental contact between the two solids is broken by the reaction. The reduction of metallic oxides by carbon is such a case. The carbon atoms touching the oxide molecules react and since the metal occupies less space than the oxide and since the oxidation product of carbon is gaseous, a gap of molecular dimensions between the solids is formed and the *direct* reaction stops. Further contacts of the same sort may be produced by accident or by deliberate stirring of the mass, but in any case such a reaction must be slow.

This type of reaction or, rather, equations for this type of reaction are to be found in every book on metallurgy and inorganic chemistry. Practical men, of course, know that carbon is the cheapest and in many cases the best reducing agent available. The way in which the reaction takes place is that carbon is oxidized either directly or indirectly to CO and the actual reduction of the oxide is done by CO gas. Hence, in order to understand what is really occurring in the chemical system, we should write,* for example:

$$Cu_2O + CO \rightleftarrows 2Cu + CO_2,$$
$$CO_2 + C \rightleftarrows 2CO,$$

instead of merely the gross result

$$Cu_2O + C = 2Cu + CO,$$

or, as is frequently done,

$$2Cu_2O + C = 4Cu + CO_2.$$

The gas in such cases contains both CO and CO_2 but the ratio is determined by the temperature and pressure and the thermodynamics of the system if the system is allowed to reach equilibrium, or by the relative rates of the first two reactions if it is not permitted to reach equilibrium. Metallurgical systems of this sort

* The air originally present in this system reacts with the carbon to form the CO or CO_2 necessary to start this cycle.

are never allowed to reach equilibrium and for this reason the matter of relative rates is extremely important. The relative rates, in turn, depend to a very considerable degree upon the physical characteristics of the substances. Thus for several reasons the ratios of CO to Cu or CO_2 to Cu may be far different from those demanded by the last two equations. Reactions of this sort have actually been studied and it was shown that if the CO concentration or pressure was prevented from building up by continuously pumping the system down to very low pressures, practically no oxide was reduced.

In leaching operations we meet with analogous situations. For example, in leaching of certain ores containing $CuCO_3$ and metallic copper, with ammonia solutions, the chemical equation is sometimes given (with another wrong formula) as

$$2NH_3 + CuCO_3 + Cu = Cu_2CO_3 \cdot 2NH_3.$$

Since both copper and $CuCO_3$ are solids the chances of having all three substances in the right position to react at a given moment seem remote and it would be difficult to understand how the reaction could proceed at a rate sufficient for practical purposes if this be the mechanism. On the other hand, it is easy to understand if we consider the reaction to take place by a series of steps as follows:

$$CuCO_3 + 4NH_3(aq) \rightleftarrows Cu(NH_3)_4^{++} + CO_3^{=},$$
$$Cu(NH_3)_4^{++} + Cu \rightleftarrows 2Cu(NH_3)_2^{+}.$$

The ratio of $CuCO_3$ to Cu actually dissolved may, therefore, have no relation at all to the gross stoichiometric equation since in practical cases it is generally not possible to get all of the dissolved $Cu(NH_3)_4^{++}$ in contact with the free metal. Further, if it were possible in any case to account quantitatively for all the ammonia introduced in the process by the copper ammonia compound recovered, there would be distinct grounds for suspecting that all the free Cu had not been dissolved.

The understanding of a chemical process depends very much on the way it is represented, and, as already shown, some of the most important features of the process may be buried entirely or be badly obscured by paying attention only to the stoichiometric requirements. A particularly good illustration of this is the desulfurization of iron in the blast furnace. The process is generally represented by the equation:

$$FeS + CaO + C = Fe + CO + CaS.$$

The equation is correctly balanced, but as soon as we inquire as to

the location of the various substances we become puzzled. The FeS and C are dissolved in the molten iron but the CaO is in the slag. Thus in order for the process to go at all there must be a series of steps.

$$\text{FeS (metal)} \overset{\text{diffusion}}{\rightleftarrows} \text{FeS (slag)},$$

$$\text{FeS (slag)} + \text{CaO (slag)} \rightleftarrows \text{FeS (slag)} + \text{CaS (slag)},$$

$$\text{FeO (slag)} \overset{\text{diffusion}}{\rightleftarrows} \text{FeO (metal)},$$

$$\text{FeO (metal)} + \text{C (metal)} \rightleftarrows \text{Fe} + \text{CO (gas)}.$$

As far as sulfur removal is concerned, the last two steps are not of the slightest importance chemically. Physically, the last step may be important because a gas is liberated, thus giving a certain amount of stirring which might influence the first step. But there is no reason for believing that an atomic weight of carbon is removed from the iron simultaneously with a molecular weight of FeS. Further, if we understand the process as a whole as the above series of steps, there is the possibility of gaining some control over the time efficiency of the process. The gross equation, however, gives no clue at all in this direction.

The kind of inorganic chemistry required for this type of critical analysis and interpretation has been included in the advanced course which I outlined earlier in this lecture. It is evident, however, that the point of view is quite as important as the actual material and that students must be trained to make independent critical interpretations of the various possibilities. I do not underestimate the difficulties of the latter task. It means that students must be trained to consider the melting points, the sublimation and vapor pressures, the physical properties in general, the tendency to decompose, etc., for each substance; the possibility of forming low-melting eutectics or compounds among the reactants and products; the formation of complex ions, the solubilities, etc., in aqueous solution; in short, every factor which may change the character of the region where the reaction takes place or the transport of material to or from that region. All these factors are in addition to the chemical reactions which may be possible among the various substances in the system.

An objection may be made to the proposal of this type, of course, on the ground that we do not know enough about metallurgical reactions to furnish material for such training. One reply is that if metallurgists do not know their reactions well enough for this purpose, the time has come when a serious effort should be made in this direction. A second objection might be that,

after all, metallurgists have been getting results for generations and they have been supplying the world with metals and alloys of such quality and at such a rate that industry could use them and develop at a sufficient pace to keep up with all other progress. Therefore, since such a knowledge of the chemistry of the processes as I have outlined and consider essential has not been available to successful practical men of the past and present, why should we be concerned now? I have the greatest respect for the practical and technical achievements of metallurgists of the past and present. In fact, I consider that civilization as a whole is much better off because metallurgists at an early date decided that they would devote themselves to the extraction of metals from the ores and the conversion of them to useful forms and let others, who aspired to more scientific knowledge, discover why the processes worked. But that day is past; improvements now depend on better understanding and new knowledge. A number of conversations with older metallurgists, men who are, at least in part, responsible for the present high state of the art, indicated that they expect this new knowledge and better understanding to come chiefly from the younger men. Much is expected of men who are being trained in the technical schools and universities of the present era. A critical analysis of the chemistry of metallurgical processes which demonstrates the unsatisfactory state of our knowledge on many important and fundamental matters is, in itself, a fine challenge to young men of scientific ability. But to meet that challenge, we, whose duty it is to train these men, must see to it not only that our students *study* more chemistry, but even more important, that they *use* more chemistry in dealing with metallurgical problems.

THE PLACE OF THE SOCIAL SCIENCES IN THE TRAINING OF ENGINEERS *

By DON D. LESCOHIER, *Professor of Economics*, University of Wisconsin

I am approaching this question from the point of view that the engineer needs social science training for three distinct purposes:

(*a*) He needs certain social science courses as a part of his technical knowledge;

(*b*) He needs certain social science courses as a part of his equipment for executive work in industry;

(*c*) He needs certain additional courses as a preparation for adequate citizenship.

It is my opinion that every college trained man should recognize the fact that he has greater responsibilities as a citizen than the less educated citizens. He should have training for this important part of his life as well as for the earning of income. In the following analysis of the scope of social science training desirable for the engineering student, the subject will be approached from these three angles.

I will lay down the proposition that certain of the social science courses should be included in the curriculum of the engineering student, even if some of the engineering courses now given have to be dropped. Careful analysis of the curricula of technical and professional schools ordinarily reveals that some courses are being required which have become obsolete in whole or in part, and others which go into advanced technical knowledge can not be assimilated by the inexperienced college student and are forgotten before the young engineer or doctor or lawyer are mature enough to make use of that technical knowledge. A cold-blooded analysis of the engineering curriculum in your schools would probably reveal that there are parts of it which could be eliminated without impairing the practical technical knowledge of your graduates to make way for subject matter of greater value to them in their work as engineers and in their functions as citizens.

Social Science Courses as a Part of the Engineer's Technical Knowledge

We will consider first, what courses in the social sciences have a technical importance to the engineer. Some of these are in-

* An address delivered at the Mining and Metallurgical Session of the Summer School for Engineering Teachers, University of Wisconsin, July 7, 1933.

cluded in the curricula of different engineering schools, others are not.

A year's work in general economics is of fundamental importance. This should include a survey of our economic institutions and problems, such as transportation, taxation, public utilities, wages and hours, tariff, labor problems, as well as an analysis of the theoretical principles of economics. At first thought, some engineers may question the practical usefulness of economic theory to the engineer. The experienced student of any technical field knows that you can not resolve the practical problems and issues which come up unless you have a thorough understanding of the basic principles and theories of that field of thought and life. Take for instance the problem which has confronted the United States during the past few years of expanding public works on a gigantic scale to relieve unemployment and to bring about business recovery. Consideration of this problem requires some answer to such questions as these: What effect will the expansion of public borrowing necessary for such a public works program have upon the credit opportunities of private business? How will it affect prices? Would it be better to finance a large part of the public works by the issuance of inflation money? What hours should be worked on public projects? What wages should be paid? Should the government plan to pay off these new debts over a period of twenty or thirty years or should these be wiped out within three or four years after the end of the depression, so that new borrowings can be undertaken when another depression comes upon us? One might easily amplify the list of problems that arise in connection with this public works program. One who is ignorant of the principles of economics lacks some of the tools which are necessary to work upon such problems. The engineers, because they play so large a part in the planning and management of both public and private construction projects, should be able to make intelligent judgments upon the economic as well as the engineering side of these problems. In fact they are forced to do so.

The engineer should have an intelligent *historical* picture of the economic and industrial evolution of our present economic world. During the past three years I have talked with many engineers who were baffled by the rapid technical, economic and political changes which were going on around them. They were asking whether we were headed toward some great political and economic revolution. They were asking whether the world was in an economic chaos from which there could not be any satisfactory escape. They were asking how all this came about and in what direction we had to go to find a way out. A knowledge of

the economic history of this country and of the modern industrial world gives one an understanding of the processes which are going on and enables one to see the direction of present evolution more clearly. When such a problem as technocracy or the present federal industrial control bill or the farm allotment plan is under consideration or being carried out, the engineer must be able to apply more than engineering knowledge. He must have more than engineering background. A historical prospective is as essential as an understanding of current engineering and economic principles.

The third field in the social sciences which should be a part of the engineer's technical equipment is an understanding of taxation and public expenditures. The American people are woefully ignorant of their tax system and of the financial operations of government. A considerable part of public expenditures is for work managed by engineers, such as the highway work, building construction, drainage, and the laying-out of cities and subdivisions. Engineers are necessarily involved in economic as well as engineering planning and management. It is an unfortunate thing when engineers, lawyers and other types of citizens who play an important part in the control of public financial operations are ignorant of the economic characteristics of taxation, public expenditures and public debts, or have merely a scrappy knowledge which they have picked up in the course of their experience. They require a thorough ground work of knowledge of the principles and problems of public finance upon which to build through experience a technical knowledge of public finance.

Closely related is a knowledge of government, particularly state and local government. The modern engineer should have at least a year's work in political science, with particular attention to state and municipal administration. Most of us pick up a fair knowledge of the elective and judicial side of government, but the engineer who may work with governmental bodies or at least have occasion to do business with governmental bodies from time to time should have a technical knowledge of the administrative set-up and principles of state, city and county governments. This, combined with a general knowledge of economics and special training in public finance will enable him to be of constructive value to the community as well as a more competent engineer.

The next field in which the engineer requires technical knowledge is that of industrial relations or labor relations. Every engineer should study the history and problems of the labor movement. He should know why unions have been an important factor in our industrial life for about 130 years. No social institution lasts that long as a vigorous and active agency unless important

reasons have brought it into existence and require its continuance. Engineers should know why labor unions exist, what their policies and objectives are, and have an intelligent understanding of the relations which employers may set up with the unions. There are very few engineering students who are receiving as a part of their curriculum a careful and impartial analysis of the problems connected with unionism. Similarly the causes and characteristics of restriction of output, of labor turnover, of unemployment and irregularity of employment, of the hours of labor problem, and of the various methods of wage payment are all matters of major importance, requiring considerable study for their thorough understanding. Each of them enters into the experience of every engineer, for all engineers are in charge of larger or smaller forces of labor. Consider, for example, the question of restriction of output. A great many people believe that restriction of output was originated by and perpetuated by labor unions. Nothing is farther from the truth. The restriction of output is as common among unorganized as among organized workers. It is due sometimes to the unwillingness of people to work harder than they need to. It is due, more importantly, to the desire to make the job last and avoid unemployment or to a fear that the piece rate will be cut if the person does his best and that he will only work harder for the same amount of money. It is due, further, to a failure of industry to open opportunities for promotion and permanent employment. These observations merely touch some of the outstanding aspects of the problem of the restriction of output. They illustrate the type of technical questions which must be investigated by engineers who wish to become competent in the handling of labor relations. Unless engineers are competent in handling labor relations they can not keep costs at a minimum and maintain efficiency at the practical maximum.

Every engineer should have a thorough course in personnel management which should cover all aspects of the handling of labor. He should understand the causes of strikes in the United States and the different types of strikes, the causes of labor turnover, absenteeism and tardiness, and have a good knowledge of the policies which have been developed by various concerns for handling these problems successfully. An understanding of psychology is, of course, indispensable and the personnel management course should be preceded by a basic course in psychology. It should include a study of fatigue and the conditions in modern industry which cause undue fatigue and methods of fatigue control. Such technical questions as the frequency and length of rest periods in work carried on at different degrees of speed and intensity are as important in technical training as an understanding of the peculiarities of iron or copper or of energy.

Social Science Courses as a Part of the Engineer's Equipment for Executive Work

All of the preceding discussion has centered around the engineer as a technician. We have suggested various fields of study which are a necessary part of his professional training. We will now consider the engineer as an industrial executive. In this capacity he requires a broader outlook than the engineer as a technician. As an industrial executive he must solve the problems connected with the continuation and the successful operation of the business. A study of the nature, causes and control of the fluctuations of business prosperity, which we have now come to call business cycles, is a vital part of the equipment of industrial executives in the years that lie ahead of us. I have been much impressed by the reports of a committee of the American Engineering Council upon the current business depression which were published in *Electrical Engineering* for June 1932 and May 1933 and in the June 1932 and the April and May 1933 issues of *Mechanical Engineering*. If any of you have not read those reports I would suggest their very careful study. They constitute a searching analysis of our present economic difficulties. They do not cover all aspects of the situation but they illustrate the contribution which engineers can make to our analysis of and efforts to control business depressions. The economist alone will not give a satisfactory answer to the questions involved in business cycles. An analysis of business depressions requires the technical knowledge of economists, engineers, political scientists, bankers, business men, labor leaders and many other classes of citizens who can approach the problem with special technical knowledge and experience.

Another field of social science that should be studied by the engineer to fit him for executive work is briefly summarized in the words capitalism, fascism and socialism. The world appears to be at one of the turning points in history. If we go back 100 years to the post-Napoleonic war era, we find that Europe was torn for a generation by revolutions and counter-revolutions, by movements and conspiracies arising in a widespread conviction that the old political and economic order had served its time and should be scrapped for new political and economic institutions. The history of Europe between 1815 and 1850 is not dissimilar to that of the world today. The nations were buried in war debts, the economic structure was disorganized, and the competition of the new world was upsetting the agriculture and industry of Europe. The movement to establish republican governments, which had found its first practical expression in the American republic and subsequent expression in the French republic and in a long

series of revolutionary movements in other countries finds its counterpart in our own time. Again the world is buried with debts, public and private; again we are seeking to solve our economic miseries by still further expansion of public debts and public employment; again we find political unrest which has already culminated in the Communist revolution in Russia and the Fascist revolutions in Germany and Italy and the establishment of practical dictatorships in half a dozen other countries. Our young engineers who are destined to play such an important part in the industrial management and economic policies of the United States should have some understanding, before they begin their careers, of the great struggle which is going on in the world between different forms of government and different types of economic systems. It is a crime against humanity to allow such a large proportion of college graduates to go out into the world with no systematic study of the biggest events that are occurring in the world at the present time.

The Communist and Fascist movements in Europe are no more radical for our time than the republic of America was in the eyes of Europe a century or more ago. No men can forsee what the social evolution of the next fifty years will bring forth. We know that it will bring forth change. We know, furthermore, that the changes which will occur will be due to the concensus of public opinion in the different nations rather than to the leadership of Mussolinis or Hitlers or Roosevelts. These men can direct in part the trend of evolution, but they can proceed no faster than the great body of citizens is willing to go. Mussolini has been able to carry out his policies in Italy because a large body of Italian citizens is in sympathy with those policies. Hitler in Germany, Stalin in Russia and Roosevelt in America are in the same position. The engineers of the United States must understand these great social issues and movements. Their strategic importance in American life demands it of them. I look upon the study of business cycles and the study of capitalism, fascism and socialism as a part of the proper equipment of an industrial leader of the next generation.

Social Science Courses as a Preparation for Citizenship

We come now to the third approach, the engineer as a citizen. It is apparent that the fields of study which I have suggested as necessary to the technical training of the engineer and to the proper outlook of the industrial executive are also of vital importance to the engineer as a citizen. The point that I would emphasize particularly in this connection, is not a list of courses

which the engineer should take to prepare himself for citizenship, but an emphasis in the engineering colleges upon the social responsibilities and civic opportunities of engineers as citizens. Both their training and the positions they will hold fit them for leadership. In this age of mathematics and science, those citizens who are trained in scientific fields and who control the technological development of our civilization have a peculiar prestige in the eyes of the general public. The throngs of people in the Science, Transportation and other buildings at the Century of Progress Fair devoted to technical advancement, give vivid testimony to the current interest of the American people in technology and their respect for technical progress. Those citizens who are in positions of technical leadership are likewise in positions of social leadership. The young engineer's attention should be focussed upon this aspect of his life as well as upon his professional training and duties.

This brings me to the question, why have the social sciences played so small a part in the training of engineers? You know more than I do about the history of engineering schools, but there are certain things that I see which seem to me to be a partial analysis of this question. Our colleges of engineering developed at a time when the social sciences played but a small part in the training of any kind of college graduates. Most of the development in social sciences has come during the last twenty-five years. It is but recently that medical and law schools have become aware of the importance of the social sciences in the training of doctors and lawyers. It is but recently that schools of education have realized the importance of the social sciences in the training of teachers of all subjects.

Engineering itself has been expanding so rapidly that the engineering schools have found it impossible to crowd into a four year course all of the engineering subjects which they deemed desirable in the training of an engineer. On the other hand, the engineering schools have been guilty of the same error characteristic of many other fields of education. A course once established has become quasi-sacred. It has been difficult to eliminate. Frequently a personal question was involved. There was a fear that some professor's feelings might be hurt if a certain course or part of a course was deemed non-essential. Mere inertia has prevented the reconsideration of the curriculum from time to time which might have eliminated some less important subject matter. I challenge you engineering teachers to face the question in your respective schools and to analyze your curricula to discover whether all that you require is really more essential than some other fields of study which might be substituted for a part of your technical

course. I challenge you to consider whether you are trying to teach some engineering subject matter which can not be comprehended adequately by the inexperienced engineer and should be deferred to be taken in graduate or extension courses or by private study after the engineer has obtained some practical experience.

I suggest that the important thing in engineering courses is to turn out young engineers who are capable of learning from their experience and who will develop with experience and will study after they leave the university, rather than to try to cram into the embryo engineer a vast amount of engineering knowledge, especially of fine details which he can not assimilate and for which he will have no use during the early years of his engineering experience. I suggest further, that no engineer will make a success because of what he learned in college. His success will depend upon what he learns afterward. The function of his college course is to teach him how to learn, and to inspire him with a thirst for engineering knowledge, and to give him a vision of the possible career of a first-class engineer. I suggest further, that that vision must include a picture of the engineer as an industrial executive and business man and of the engineer as a constructive citizen, as well as a picture of the engineer as a technician.

NEW MEMBERS

BAINER, ROY, Assistant Professor of Agricultural Engineering, University of California, Davis, Calif. H. B. Walker, J. S. Long.

BARNES, GEORGE ERIC, Professor of Hydraulic and Sanitary Engineering, Case School of Applied Science, Cleveland, Ohio. Wm. E. Wickenden, Theo. M. Focke.

BECKER, SYLVANUS A., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. F. V. Larkin, H. M. Sutherland.

CONKLING, LEON D., Professor of Civil Engineering, Montana State College, Bozeman, Mont. W. M. Cobleigh, Eric Therkelsen.

DAVIS, HARMER E., Instructor in Civil Engineering, University of California, Berkeley, Calif. Raymond E. Davis, H. B. Langille.

DRURY, CHARLES W., Manager, Deloro Research Laboratories, 521 Bloor Building, Toronto, Ont. F. L. Bishop, Nell McKenry.

HOLT, CLIFFORD B., JR., Instructor in Electrical Engineering, Pennsylvania State College, State College, Pa. A. M. Dudley, L. E. Doggett.

HUMMEL, JOSEPH O. P., Instructor in Industrial Engineering, Pennsylvania State College, State College, Pa. R. L. Sackett, C. E. Bullinger.

LURIE, ARNOLD N., Head, Drawing Department, Tilden Technical High School 6120 Ellis Ave., Chicago, Ill. F. L. Bishop, Nell McKenry.

NEYHART, AMOS E., Instructor in Industrial Engineering, Pennsylvania State College, State College, Pa. R. L. Sackett, C. E. Bullinger.

OLIVER, FRANK J., Industrial Coördinator, University of Detroit, Detroit, Mich. C. J. Freund, H. O. Warner.

PETERSON, ANDREW I., Supervisor of Property, New York University, New York City. Collins P. Bliss, Wm. R. Bryans.

ROUNTREE, HARRY C., Instructor of Engineering Extension, Pennsylvania State College, Erie, Pa. J. O. Keller, A. H. Zerban.

SLADE, JAMES J., JR., Assistant Professor of General Engineering, Rutgers University, New Brunswick, N. J. P. H. Daggett, H. D. Hatfield.

STUBBS, FRANK W., JR., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. W. C. Huntington, M. S. Ketchum.

TEARE, B. RICHARD, JR., Instructor in Electrical Engineering, Yale University, New Haven, Conn. Fred J. Beck, A. G. Conrad.

WILSON, BIRTON N., Professor of Drawing and Architecture, University of Arkansas, Fayetteville, Ark. W. B. Stelzner, W. R. Spencer.

NOTE TO THE SECRETARY

The Secretary received many notes of appreciation of the 20% reduction in dues authorized by the Council. The one given below is typical:

"Thanks a lot for the reminder dated January 2. It saved me one dollar. I am enclosing a stamp to pay the postage of your reminder. That is the least I can do for what you did for me."

COLLEGE NOTES

The **Case School of Applied Science** recently honored Professor Fred Hale Vose upon his completion of a quarter of a century of service on the faculty at a banquet given by the Case Chapter of the American Society of Mechanical Engineers.

Speakers lauded Professor Vose upon his extensive career as engineer and educator. Among them were Dr. Wm. E. Wickenden, president of Case, Dean T. M. Focke of Case, and Dr. Chas. Sumner Howe, president emeritus of Case. Mr. F. A. Quail, president of the board of trustees, acted as toastmaster.

Speeches were followed by the presentation of a lounge chair to Professor Vose by the students and faculty of his department.

Professor Vose was called to Case in 1909 as assistant professor of mechanical engineering. He was advanced to his present position as professor and head of the Mechanical Engineering Department three years later. He designed the Bingham Laboratory of Mechanical Engineering of Case, one of the most completely equipped of its kind in the country.

One of the outstanding achievements of the **Colorado School of Mines** during the past year is the discovery of a method of controlling grinding and crushing of ore. Research on this problem was conducted in the laboratories of the school's experimental metallurgical and oredressing plant under the directorship of Arthur J. Weinig. The results have been published by the School of Mines in a bulletin, "A Functional Size-analysis of Ore Grinds," written by Mr. Weinig.

University of Detroit.—A Department of Engineering Research—Division of Chemistry, Chemical Engineering and Metallurgy—is announced by the University of Detroit. Dr. Henry L. Coles, assistant professor of chemical engineering, has been appointed director. This department was established in order to make available to industry the facilities and personnel of the University for the solving of research problems and the carrying on of analytical and testing work. Typical research procedure will include a thorough study of the literature of the subject, preliminary conferences with the manufacturer and visits to his plant, the submission to the manufacturer of a plan of investigation, and finally, the experimental and developmental work, carried on first in the laboratory and then on a full-size scale in the factory.

The Research Department is prepared to provide analytical service on all raw materials entering into manufacture and on finished products, such as coal, paint, minerals, lime, fats, oils, soap, textiles, food, fertilizers, cosmetics, steel, cast iron, and non-ferrous metals. The department is particularly well equipped to handle problems pertaining to steel and some of its unusual alloys. Special service, either direct or advisory, is also offered on all matters pertaining to the control of plant output—thus giving assurance of uniform raw materials and of properly maintaining details of operation in the interest of low products cost and of the saleable character of the output.

Firms, individuals, or trade associations are invited to establish fellowships for the purpose of studying special problems for which the usual plant laboratory is not equipped. Five hundred to one thousand dollars will be sufficient to establish the average fellowship, depending on the nature of the problem to be studied.

In general, testing and analytical service costs will be in line with those charged by the usual public testing laboratories. All work will be under the supervision of the director, but much of the details will be carried on by recent graduates and coöperative engineering students.

Determination of the complete heat balance of an internal-combustion engine is an unique laboratory problem in automotive engineering for senior mechanical engineering students at the University of Detroit. The test was devised by Prof. Francis J. Linsenmeyer, department head, and goes much further than A. S. M. E. and S. A. E. test procedures for such engines in that the attempt is made to subdivide the original fuel energy into all its ultimate forms. Since losses account for fully three quarters of this energy, the importance of measuring these losses, as well as developed useful power, is apparent.

A standard Ford Model A 4-cylinder engine is used, coupled to an electric dynamometer, and observations are made for full-load conditions. To acquaint the student with the operation of the apparatus, a simple horsepower test is made in the first laboratory period. In the second, an efficiency or ecenomy test is run in conformance with S. A. E. test standards. These preliminary runs gives the students familiarity with carburetor regulation to obtain the optimum condition of maximum CO_2 and the minimum CO in the exhaust. A standard Orsat analyzer is used in which the air-fuel ratio is determined by the progressive absorption and quantitative analysis of the O, N, CO_2, and CO in the exhaust gases. In the third and final run for determination of heat balance, a check analysis is made in the more accurate Fisher analyzer from a bottled sample of gas collected over water.

In calculating this balance, the student determines the higher B. t. u. value of the fuel in a calorimeter as the starting point and attempts to measure and compute the various forms in which the energy is used or dissipated: in developed or brake horsepower, in engine friction, in the cooling water, in the exhaust gases and in the oil. Radiation losses are unaccounted for. The dynamometer permits measurement of brake horsepower. Mechanical losses in the engine are measured by driving the idle engine through the dynamometer operated as a motor. This arrangement is only an approximation to a true running condition as the bearing loads are different without the explosion pressures, the pistons are cooler, and the oil tends to cool rather than heat up, but this is the only practical method and is sufficiently accurate for the purpose.

Cooling water circulates through the engine to an overhead tank to which a fresh supply of cold water is added. A meter reads input water in gallons which is converted into pounds, and the difference between inlet and outlet temperatures to and from the engine gives the rise from which the B. t. u. loss is computed.

Particular attention is paid to an accurate determination of exhaust gases' losses, both sensible and potential. Sensible losses are due to temperature rise only; potential, to the unrealized heat content of unburned combustible gases. In calculating the former, inlet air and exhaust temperatures are taken into account together with the air-fuel ratio. Knowing the pounds of fuel consumed per hour and the pounds of air required per pound of fuel, as determined by the Orsat analyzer, the student computes the pounds of gas discharged per hour and from these figures the B. t. u. loss.

Potential losses are often ignored in tests of this kind, but chemical analysis indicates that significant amounts of free hydrogen, methane and a series of aluminants are present in the exhaust owing to progressive cracking of the fuel during explosion. The aluminants, composed chiefly of benzine, C_6H_6, and ethylene, C_2H_4, are present in small quantity, however, and can generally be ignored. Hydrogen and methane are determined in the chemical laboratory in the Fisher analyzer, which also measures the percent of CO, CO_2 and O. Since the gas sample is collected over water, it is a saturated gaseous mixture at room temperature, and this condition precludes measuring the amount of hydrogen burned to water and exhausted as superheated steam. This energy loss plus radiation losses are unaccounted for and average 6 per cent of the total energy. Incidentally, the engine is run without its own cooling fan; instead an electric fan blows air over the engine.

Heat losses in the crankcase oil are computed by taking temperature readings at start and end of the test, but no attempt is made to estimate the energy supplied the engine by lubricant that

is burned in the cylinders, amounting to about a pint an hour under full-load conditions. The error from this source is about 1 per cent.

A Maihak indicator produces a diagram that approximates the "indicated" horsepower, but is chiefly useful in studying valve conditions, rather than as a check upon brake horsepower and engine friction losses.

This heat balance test takes into account every energy loss that is capable of measurement without undue complication, such as would be necessary to measure radiation losses. Based upon the principal of conservation of energy, it demonstrates fundamentals that the student generally finds applicable only in steam power plant heat balance tests which the University of Detroit engineering students study in the usual way in a separate laboratory course.

University of Idaho.—On August 15 Ivan C. Crawford, Dean of the College of Engineering, University of Idaho, was granted a year's leave of absence to accept an appointment as State Engineer for the Committee on Federal Appropriation for Idaho. Suitable offices and office help were established in Boise from which point the work is directed. Graduate assistants were employed in each department to assist with the reapportioned teaching loads. J. Hugo Johnson, Head of the Department of Electrical Engineering, was appointed as Acting Dean.

University of Illinois.—Due to continued ill health, Dean Milo S. Ketchum asked to be relieved of his responsibilities as Dean of the College of Engineering and Director of the Engineering Experiment Station at the beginning of this current school year. He is now a member of the Department of Civil Engineering and holds the position of Research Professor of Civil Engineering. Professor A. C. Willard, Head of the Department of Mechanical Engineering, was elected as Acting Dean of the College and Acting Director of the Engineering Experiment Station in his stead. Dean Willard still remains as Head of the Department of Mechanical Engineering and is dividing his time between the two positions.

Dean Willard came to the University in 1913. Since 1917 he has been Professor of Heating and Ventilation and since 1920 has also been Head of the Department of Mechanical Engineering. He has had wide experience in both the teaching and practice of engineering. One of his most interesting projects was the preliminary study and investigation, as Consultant on Ventilation, of the design of the ventilating system for the Holland Vehicular Tunnel under the Hudson River in New York City. Dean Willard is co-author with Professor L. A. Harding of several textbooks entitled: Heating, Ventilating and Air Conditioning; Mechanical Equip-

ment of Buildings, Vol. 1, Heating and Ventilation, and Vol. 2, Power Plants and Refrigeration. He has also contributed many bulletins, pamphlets, and articles on the subject of heating and ventilation.

Dr. Ketchum was graduated from the Civil Engineering Department of the University of Illinois in 1895. From the date of his graduation until 1903 he spent a part of his time in teaching in the Civil Engineering Department here and the remainder in active practice in Structural Engineering. In 1903 he became Professor of Civil Engineering and in 1904 Dean of the College of Engineering of the University of Colorado and remained in that position until 1919. During 1918–19, while on leave of absence from the University of Colorado, he was appointed Assistant Director of U. S. Government Explosive Plants and was made representative of the Secretary of War in the construction of the smokeless powder plant at Nitro, West Virginia. In September, 1919, he became Professor of Civil Engineering and Director of the Department at the University of Pennsylvania. In 1922 he was called back to his Alma Mater to become Dean of the College and Director of the Engineering Experiment Station, which position he held until his recent resignation on account of illness.

While carrying on his teaching and administrative duties, Dr. Ketchum has found time to do extensive writing. He is the author of five books used as texts in structural engineering that are entitled as follows: Structural Engineers' Handbook, which has had an exceptionally wide distribution among student and professional engineers and which is now in its fifth edition; Design of Steel Mill Buildings and the Calculation of the Stresses in Framed Structures; Design of Highway Bridges of Steel, Timber and Concrete; Design of Walls, Bins and Grain Elevators; and Design of Mine Structures. He is co-author with Professor W. D. Pence of a textbook in surveying called Surveying Manual. In addition he has contributed many articles for engineering magazines. Dr. Ketchum served as President of the S. P. E. E. during 1917–18.

University of Maine.—The following committees in the College of Technology have been organized: Curricula; Laboratory Practice; Personnel Problems; Academic Procedure; Professional Status of the Engineer; Academic Tenure.

One of the outstanding accomplishments of the Committee on Academic Procedure has been the tentative adoption of comprehensive examinations for sophomores and for seniors.

Massachusetts Institute of Technology.—Under the leadership of Professor J. H. Zimmerman, the Department of Mechanical Engineering is starting a course in welding. Heretofore the weld-

ing laboratory has been used only in conjunction with other courses and never for a separate course devoted to welding engineering and its applications. As work progresses pioneer research will be carried on by students and the staff.

Internationally known as one of the foremost practitioners in the field, Sir Raymond Unwin has recently delivered a series of lectures in the Institute's new Course in City Planning. He gave five public addresses on "The City as an Expression of Corporate Civic Life"; "Nothing Gained by Crowding"; "Regional Planning and Zoning"; "Residential Developments" and "The Place of Imagination in City Planning."

In 1929 he was made technical adviser to the Greater London Regional Planning Committee. He is a former head of the Town Planning Institute, and is a Fellow and former President of the Royal Institute of British Architects.

Dr. Jerome C. Hunsaker, Head of the Department of Mechanical Engineering, has been appointed to a special committee on aircraft hazards due to electrical phenomena, organized by the National Advisory Committee for Aeronautics at the request of the United States Navy Department.

The committee will review the whole field of electrical effects on aircraft, especially with reference to high frequency influences, and will make recommendations regarding a research program. The group comprises, in addition to Dr. Hunsaker, the chief of the U. S. Weather Bureau, the Director of the Bureau of Standards, and representatives of the Navy Department and Johns Hopkins University.

Amateur radio operators in this country and Canada are cooperating as auditors in a unique series of short wave broadcasts from Technology's meteorological airplane on its daily flights to a height of nearly four miles over Boston.

In what is considered by the American Radio Relay League to be the most important study ever made of the behavior of ultra-high-frequency waves at known altitudes, vocal messages are transmitted every morning on a wavelength of five meters, at intervals of 500 feet, from ground level to the plane's ceiling of 20,000 feet.

The "flying laboratory," piloted by Henry B. Harris, leaves the East Boston Airport at 7:30 o'clock each morning on its regular flight to secure weather data. On his outbound trips, Pilot Harris reports meteorological findings direct to the Institute's station atop the Daniel Guggenheim aeronautical laboratory. Descending, special messages are broadcast for amateurs.

Holding one of the first meetings of its kind ever to come under the auspices of the American Institute of Electrical Engineers, on December 9th the Technology chapter of that organization was host

at a convention which was attended by most of the student chapters in the New England area.

Student papers were presented on "Electrical Prospecting," the "Electric Brain," and "High Tension Transmission."

Dr. Robert J. Van de Graaff, principal speaker of the afternoon described his experiments at Round Hill in the field of high voltage electrostatic generation.

At the dinner meeting of the convention, held Saturday evening in Walker Memorial, Mr. C. A. B. Halvorson of the General Electric Company described the progress that has been made in the study of sodium light.

The entire program met with such enthusiastic success that the student convention is to be made an annual affair.

University of North Carolina.—Dean H. G. Baity, of the School of Engineering, has been appointed State Engineer for the Public Works Administration. During his absence, Professor William J. Miller, Head of the Electrical Engineering Department, is serving as Acting Dean of the School.

Dr. Gail P. Edwards is serving this year as Visiting Associate Professor of Municipal and Sanitary Engineering. Dr. Edwards comes to the University after nine years with the Sanitary District of Chicago and a year of special study at Harvard in 1932–33. He replaces Prof. Harry N. Jenks who has returned to consulting practice with his firm in San Jose, California.

Northeastern University.—The five year curricula in engineering and business administration are now in full operation. About 300 seniors, members of the first class to graduate from the new programs, will receive their Bachelor of Science degrees at the Boston Arena in June, 1934.

A survey of the 412 members of the class of 1932 just completed by the Alumni Secretary, Rudolph O. M. Oberg, indicates that 78 per cent of the class are now regularly employed. As far as undergraduate employment is concerned, the Department of Cooperative Work reports an increase of 25 per cent in coöperative work placements over a year ago. There has been an increase of 51 per cent in the number of employing firms and the area over which the students are spread at coöperative work is larger than it has been for several years. In addition to the companies that have resumed coöperation with the University this fall, 18 new employers have begun coöperative relations since September first.

The faculty of the Day Division have raised, by voluntary subscription, the sum of $300 which will be increased by other subscriptions, interest on which will be used annually to provide a

prize which will be awarded in memory of the late Professor William J. Alcott, Jr., to the student who has shown the greatest distinction in mathematics during the school year. Professor Alcott, who served as a member of the mathematics department for eight years, died last October after a lingering illness caused by injuries he received in the World War.

An innovation at Northeastern University this fall is a series of faculty luncheons scattered throughout the school year. No formal program is planned but the luncheons are intended to provide an opportunity for social intercourse and the informal discussion of mutual problems. At one of the first of these luncheons Dean Ell recounted his experiences on a western ranch last summer, showing motion pictures of the life there.

Recent additions to the Board of Trustees at Northeastern University include:

Carl Dreyfus—New England representative of the Hearst newspapers.

Edward J. Frost—Vice President and Director of William Filene's Sons Company.

Charles R. Gow—former Postmaster of Boston, President of Warren Brothers.

Harrison P. Eddy—senior partner of Metcalf and Eddy.

Frederick H. Fay of Fay, Spofford, and Thorndike.

Messrs. Gow, Eddy, and Fay comprise the committee of the trustees on the School of Engineering.

University of Southern California.—Philip S. Biegler, Dean of the College of Engineering of the University of Southern California, has been granted sabbatical leave during the second semester 1933–34. He will spend the semester at the University of Florida in work such as Economics, Sociology, and Psychology rather than in engineering study. The objectives of this program is to learn more of what is offered in these related fields, of value to engineers. Professor Thomas T. Eyre, Head of the Department of Mechanical Engineering, will be acting Dean during the second semester.

STANDARDIZATION OF SYMBOLS AND ABBREVIATIONS

Our Society is one of the Sponsors of the subject project, called Project Z-10, of the American Standards Association, with a regularly organized Sectional Committee. The writer has been the representative of the Society for many years, and it seems desirable at this time that a report be made on the progress of the Project to date, and the future plans.

The Project, as originally planned, has been completed, and the officers and committees have brought through to adoption by the American Standards Association, as American Standards, or tentative American standards, a number of lists.

One branch of the work relates to symbols and signs for equations and formulas, and lists have been issued for the following subjects:

Mechanics, Structural Engineering and Testing Materials,
Hydraulics,
Heat and Thermodynamics,
Photometry and Illumination,
Aeronautics,
Mathematics,
Electrical Quantities.

A full description of this branch of the work, and a general account of the fundamental principles of symbology are given in ENGINEERING EDUCATION, January, 1932. The lists themselves may be secured at a nominal price from the American Standards Association, 29 West 39th St., Manhattan, N. Y., as well as reprints of the article.

The lists above given practically complete the work in this branch, so far as American standardization is concerned. However, there remain a few subjects in which symbols need to be established; and revisions of the lists already issued will, of course, have to be provided for. Furthermore, there is a very important subject of international standardization. The lists thus far issued, represent American proposals for presentation to various international bodies, as international standards. Work must be done, in support of these lists in international bodies, in acceptance of changes which are found inevitable in order to secure international unanimity, in promulgation of the international lists in the United States, and in securing adherence to them for the sake of unanimity. There have already been formed international committees

with respect to this subject, by the International Electrotechnical Commission, and by the International Physical Union who have established a so-called S. U. N. Committee on Symbols, Units and Nomenclature. At a recent meeting, it was recommended that the project be continued with the original organization, so that this work may be carried on. This recommendation was concurred in at a meeting of the Committee on Scope of the Electrical Standards Committee of the American Standards Association, and will no doubt be agreed to by all of the sponsors of Project Z-10, as well as by the Council of the American Standards Association.

Another branch of the work relates to graphical symbols. These are used on drawings as short-hand expressions of various objects. Five lists have been issued in this branch of the subject. There has been some overlap of the work in this project, with the work of the Electrical Standards Committee. It was recommended that the Sectional Committee of Project Z-10, while it continue with the branch of work above mentioned, relating to symbols and signs for equations and formulas, release the work on graphical symbols to some other committee which it is proposed be set up for this purpose.

A third branch of the work relates to abbreviations for scientific and engineering terms, and a list has been issued with this title. It was impossible to secure complete agreement on a list of abbreviations, so this list was issued as a code of recommended practice, to be adhered to so far as individual conscience would permit. Most of the abbreviations in the list relate primarily to scientific and engineering work, and it was suggested that such abbreviations be retained by the original committee of Project Z-10. Other abbreviations, particularly those used on drawings to represent objects, would better be handled by the new committee to work on graphical symbols. The exact line of demarcation was not worked out and was left as a matter for future clarification.

SANFORD A. MOSS, *Representative.*

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

SCENE: Fraternity house, late evening following the football game. A professor (supposed to be a chaperon), and alumnus (obviously prosperous), and a freshman engineer (without a date) find themselves in an upstairs lounge.

Alumnus (heartily): Well, Professor, are you still flunking freshmen in descript?

Freshman (with some heat): I'll say he is! What burns me up is the uselessness of descript. Why do they have it in the course?

Alumnus (with a sly twinkle in his eye): That same thing bothered me, kid! I have weathered the depression so far, and I have yet to discover any use for descript.

Professor (wearily): I suppose in your work Calculus is essential?

Alumnus (hastily): Oh, that's different! Mathematics is the basis of engineering!

Freshman (eagerly): That's right. Everybody says so. Even our math prof says ——

Alumnus (sternly): Don't interrupt, kid. Let's hear what *this* prof says.

Professor (very wearily): Bear this in mind: the value of subjects studied in college is too often measured by engineers in terms of frequency of practical application, and too seldom in terms of mental development. Not one engineer in ten uses Calculus, yet Calculus is considered an important element in engineering training. Five engineers out of ten use the principles of descript every day, and yet, like you fellows, are wondering why it is included in the course.

Freshman (astonished): But how do you explain that! All the alumni claim they never use it.

Professor: No, not all. I know alumni who use descript; I know alumni who think they are not using descript but are in fact using it every day; and I know alumni, like Bob here, who are not *using a single subject* studied in college but who are using the abilities developed by such study.

Alumnus ("Bob"): If descript is worth something, why is everyone forever "panning" it?

Professor (arising and preparing to resume his duty below): I wonder. (He retires quoting enigmatically "Now is the time for all good men . . .")

From the preface of a recent text: "There is probably no subject in the curricula of colleges, at least of engineering colleges in the last twenty-five years, that has had a more unsatisfactory reputation among students than has descriptive geometry. When descriptive geometry is mentioned to the average graduate, he seems to have but little interest or knowledge of the subject and often expresses bitter memories of the course. The practicing engineer usually confesses complete inability to apply the principles of the subject to the solution of the practical problems of every day life. This lack of understanding and appreciation of the subject has resulted, through pressure brought both by students and by alumni, in the reduction of the course from a two or three semester one to the present one semester, in the large majority of the schools and colleges in America.

"This text is an attempt to overcome this antipathy that has grown around the subject. It is not claimed that the entire field has been fully covered nor that all theorems . . ."

An opinion by the Editor: Fortunately students do not read prefaces! The above preface is but one statement of similar character made all too frequently in connection with courses on descriptive geometry. The essential point which seems to be made in this quoted contribution leads the reader to infer, at least, that teachers of descriptive geometry have failed.

Perhaps they have, and perhaps this failure may account for the reduction in the course as indicated in the quoted preface.

Teachers of descriptive geometry might well accept such an implication as a challenge; they might find it worth while indeed to make an appraisal of the accomplishments in descriptive geometry since its introduction in this country at West Point in 1816. More than one hundred years of teaching, textbooks by the dozens, and as a climax to all this such an indictment as now appears in the quoted preface!

If the implications in this preface are true, teachers of descriptive geometry have little of which to be proud. The question to be settled is: Are they true?

SECTIONS AND BRANCHES

The Fall Meeting of the **Kentucky Section** of the Society was held at the University of Kentucky on Saturday, December 16, 1933, with Professor C. S. Crouse of the University of Kentucky presiding. The members of the Speed School faculty who attended were Dean Brigman, and Messrs. Ernst, Fenwick, Fife, Fisher, Houchens, Roberts, Trosper, and Wendt.

Luncheon was served at the University Commons. The program was presented by Dr. O. T. Koppius and Dr. O. J. Stewart who spoke respectively on "Physics and Engineering" and "Chemistry and Engineering." Following the general discussion on each of these subjects, the annual election was held. Professor H. H. Fenwick of the Speed Scientific School was elected President, Professor L. E. Nollau of the University of Kentucky as Vice-President, and Professor S. T. Fife of the Speed Scientific School as Secretary.

The spring meeting of the section will be held in Louisville during the K. E. A. annual meeting.

The Annual Meeting of the **Middle Atlantic Section** was held at The Cooper Union, New York City, on Saturday, November 11, 1933.

Luncheon was served at noon on the sixth floor of the Foundation Building to one hundred and seventy members and guests, including forty ladies. The ladies were entertained during the afternoon by a lecture on the Antique Musical Instrument Collection of The Cooper Union Museum for the Decorative Arts, given by Miss Lotta Van Buren, followed by music of the 16th and 17th centuries on antique instruments, played by Miss Van Buren.

The main business session convened in the Hewitt Memorial Building at two o'clock with President Cullimore in the chair, and was welcomed by Mr. R. Fulton Cutting, Chairman of the Board of Trustees of The Cooper Union.

The minutes of the Newark, Delaware, meeting were read and approved and the treasurer reported a balance on hand of $127.28.

Dr. Clarence F. Hirshfeld of Detroit, Chairman of the Engineers' Council for Professional Development, presented the work of this body, which is of a four-fold nature, dealing with the selection and guidance of undergraduate students, the engineering schools themselves, the best professional training and the matter of professional recognition by the principle engineering societies and li-

censing bodies. The principle discussions on this subject were led by Professor H. P. Hammond of the Polytechnic Institute of Brooklyn, who dealt with the matter of accrediting of engineering schools and colleges. General R. I. Rees of the American Telephone and Telegraph Company of New York, spoke on the matter of professional training of the graduate engineer, and Dr. D. B. Steinman of New York, on Professional Recognition. This was followed by much discussion from the floor which further elucidated the plans and scope of the E. C. P. D. The afternoon meeting was attended by approximately two hundred and sixty.

Dinner was served at the Hotel Brevoort to one hundred and thirty-two members. The guest of honor, Harry S. Rogers, formerly Dean of Engineering at Oregon State Agricultural College, recently elected President of the Polytechnic Institute of Brooklyn, spoke briefly and interestingly on the question of the understanding of the work of engineers by the general public. He pointed out that our responsibility as to public works does not stop with what might be called mechanical efficiency, but should include social efficiency as well.

Dean George F. Bateman, whose untiring efforts and organizing ability made this meeting a success, spoke interestingly of the life of Peter Cooper, his association with the early railways of the country and the Transatlantic Cable, and the beginnings and progress of The Cooper Union.

A committee, consisting of Professors Finch of Columbia, chairman, H. P. Hammond of Brooklyn Polytechnic Institute and Dr. D. B. Steinman, appointed to report on the Construction Industry Code and the Code for Professional Engineers, presented the following resolution:

"The Middle Atlantic Section of the S. P. E. E. at its meeting held November 11th, 1933, has considered the 'Code of Fair Competition for the Professional Engineer,' proposed as part of the general 'Code of the Construction Industry.' This code involves provisions which vitally affect the participation of engineeering teachers in civil engineering practice. Indeed as it now stands it would completely prohibit the employment of the engineering teacher in general engineering work.

"By vote of the section the Secretary of the Society is therefore requested to ask the consideration of the proposed code by council of the Society to the end that they may take such action as may seem desirable to secure a modification of sub-division (*C*) of article V of this code.

"We further suggest that the said sub-division be modified by inserting after word solicit 'nor, without the knowledge and consent of his employer, accept.'

"In addition the Section calls attention of the Council to the report of the American Society of Civil Engineers on 'The Ethics of Salaried Engineers Engaging in Private Practice' which appeared in 'Civil Engineering' for November, 1933. In particular we endorse the statement on page 644 of this publication outlining the general conditions and principles which should govern the professional activities of engineering teachers and the use of engineering school equipment."

This resolution was adopted.

The Committee on Nominations, consisting of Professors Foss of Cooper Union, chairman, Church of Brooklyn Polytechnic Institute, and Ayars of Columbia, presented the following for officers for the ensuing year.

Chairman: Morland King, Lafayette
Vice-Chairman: Frank D. Carvin, Brooklyn Polytechnic Institute
Secretary–Treasurer: Charles G. Thatcher, Swarthmore

The secretary was instructed to cast a unanimous ballot in favor of these candidates.

The Committee on Meetings, consisting of Professors Bruckner, College of the City of New York, Chairman, Lindell, University of Delaware, and Fussell of Swarthmore, made the following recommendations: That the Section meet at Haverford College, Pennsylvania, for the 1934 spring meeting, and at Stevens Institute of Technology, Hoboken, N. J., for the 1934 fall meeting. This recommendation was approved.

The Secretary was instructed to send to The Cooper Union a letter of appreciation for one of the finest section meetings in our history.

Adjournment at 8:45.

CHARLES G. THATCHER,
Secretary.

At the fall meeting of the **New England Section** of the Society, held at Durham, New Hampshire, October 21, 1933, about 115 members, wives, and non-members were present as guests of the University of New Hampshire. The attendance of members was distributed approximately as follows:

Connecticut State College	2
Brown University	7
Dartmouth College	2
Franklin University	2
Harvard University	6
Massachusetts Institute of Technology	19
University of Maine	6
New Hampshire University	8
Northeastern University	6

Rhode Island State College	3
Tufts College	16
University of Vermont	3
Wentworth Institute	1
Worcester Polytechnic Institute	2
University of Illinois	1
Wives	7
Non-Members	24
Total	115

Professor H. F. Moore of Illinois was a very welcome addition to the group.

Registration took place at the Faculty Club at 9:00 A.M., after which small groups were personally conducted to various points of interest about the University. After luncheon was served at the Commons Dining Hall, the business meeting was called to order at 2:15 P.M. in the Lecture Room of Charles James Hall (Chemistry Building), by Chairman James A. Hall. Records of the meeting of October, 1932, held at the University of Maine Orono, were read and approved. Chairman Hall appointed the following committees to report at the evening session:

Nominations: Dean Cloke, University of Maine; Professor Norton, Tufts College.

Resolutions: Professor Jackson, Mass. Institute of Tech.; Dean Bacon, Tufts College.

In line with established custom, Professor Hall directed that the Constitution of the New England Section be read for the information of new members.

President Edward M. Lewis, University of New Hampshire, extended a very cordial welcome to all guests.

Dr. Compton, President of Massachusetts Institute of Technology, presented the principal paper of the afternoon. This paper provoked much interesting discussion. Taking as his subject: "The Engineers' Council for Professional Development," he outlined first the historical development of the Council, followed by discussion of the organization and procedure which have been adopted to handle its problem. A brief resumé of the paper has been prepared by Dr. Compton and is attached hereto.

In the evening a banquet was served in the University Commons at six-thirty. After the dinner, the group adjourned to the Trophy Room, where the Nominating Committee presented their report. Professor James A. Hall was nominated and elected Chairman. The present Secretary having resigned, because of a change in the sphere of his activities, Frank W. Garran was nominated and elected Secretary.

The Resolutions Committee presented the following resolutions:

I

"The members of the New England section of the Society for the Promotion of Engineering Education in annual meeting assembled at Durham, New Hampshire, wish to express to their fellow members and friends in the University of New Hampshire their warm appreciation of the hospitality which has made this a happy day for us all.

"We wish to itemize as follows:

"We have found the beauty of the country and of the campus delightful.

"We enjoyed the thoughtfulness and the courtesy of our reception and the opportunities for viewing the plant and equipment, a model of convenience and interest.

"We extend our thanks to the University for their hospitality as we enjoyed it in the excellent luncheon served. It proved an unusually pleasant occasion.

"We wish to express our appreciation to the committee of arrangements for the program and to Dr. Compton for bringing to us an interesting and important message and for making his subject so clear and informing.

"The ladies of our party have had a good day and wish to join us in enthusiastic thanks to Mrs. Case and her committee for their entertainment.

"DUGALD C. JACKSON,
GEORGE P. BACON,
Committee on Resolutions."

II

"The New England section of the Society for the Promotion of Engineering Education wish to send most cordial greetings to our first and long continued president, Dean Gardner C. Anthony.

"At the meeting this afternoon we took the greatest pleasure in recalling both in public address and in our own memories, the times when a meeting of this kind meant to each of us a cordial hand shake and genial conversation with our president.

"This afternoon the brief constitution was again read with enthusiastic approval, especially as we recalled how Dean Anthony and President Boardman with high hand controlled our destinies as an organization to our constant benefit and enjoyment.

"DUGALD C. JACKSON,
GEORGE P. BACON,
Committee on Resolutions."

These resolutions were unanimously adopted and the Secretary, as directed, forwarded a copy of same to Dean Gardner C. Anthony.

Following the business session a stimulating address was presented by Professor William H. Kenerson, Chairman, Division of Engineering, Brown University. Drawing from his own wide experience, Professor Kenerson illustrated his subject, "The Engineer on the Witness Stand."

R. R. MARSDEN,
Secretary.

The second meeting of the **Purdue Branch** of the S. P. E. E. for the year 1933–34 was held in the lecture room of the Michael Golden Shops on the Purdue campus Monday evening, December 11, 1933, at 7:30 P.M. The meeting, with Justus Rising of the Department of Practical Mechanics presiding, was attended by forty-three persons.

The subject of discussion was "Motion Pictures as an Aid to Visual Instruction," a subject upon which Professor Rising has been working at Purdue University since January, 1926.

Professor J. D. Hoffman, Head of the Department of Practical Mechanics, related the history of the use of lantern slides from the period when they were begrudgingly admitted to use providing the instructor would furnish them at his own expense to the present time when they are considered necessary even to the extent that departmental funds may be expended for them. The classroom model was cited as a very effective aid to classroom instruction in some courses. Expense is a consideration where many different models are necessary. Professor Hoffman explained the need felt for moving pictures in connection with two courses of instruction given by his department and the steps followed in producing the films. It is notable that when the pictures were completed an immediate demand for a showing arose in surrounding schools and shops.

Professor Hoffman's remarks preceded a showing of two short sections of film; one from among those at present used in Mechanical Drawing; the other from films used in advanced Foundry Practice.

Professor W. A. Knapp, in charge of Engineering Extension at Purdue University, stated that within the limitations imposed by the available funds the movies were circulated. Professor Knapp showed films on "Technique of Playing Tennis" and "Scenes from Football Games at Purdue." The one picture demonstrating the use of films in giving instruction in sports and the other demonstrating the use of films in analyzing the efficiency of plays and players on the football field. Slow motion pictures were interjected at important points. Professor Knapp gave general quotations on cost of producing such films.

Professor G. H. Shepard, of the School of Mechanical Engineering, cited the impetus given by the moving picture to micromotion time studies for the purpose of increasing efficiency of shop workers in industrial establishments. He further mentioned that such studies led to the discovery that machines had usually been designed for the work to be performed without regard to the efficiency or comfort of the worker—this to the detriment of production. He added that analysis of moving pictures taken for time study purposes had increased the possibilities of the stop watch studies carried on prior to the advent of the movie.

Professor H. C. Peffer, Head of the School of Chemical Engineering, showed the necessity for moving pictures of the Chemical processing industries providing first hand information cannot be obtained by a personal visit to the works. Many films on these industries are available for showing, but only at specific times and for short periods. This type of arrangement does not always meet the requirements of instruction.

Professor B. H. Petty, of the School of Civil Engineering, declared the personality of the instructor and the personal emphasis given by him a prime requisite in instruction and stated that a better application of movies could be made when sound pictures and animated movies could be made practical for instructional purposes.

Mr. E. E. Reynolds, of the School of Electrical Engineering, demonstrated a small projector of slides printed on 32 m.m. film as a help in visual instruction. The apparatus complete could be carried in one compartment of a brief case.

Professor J. Rising, of the Department of Practical Mechanics, furnished a list of student comment from those who had received instruction by moving pictures. The comment was one fifth unfavorable and four fifths favorable.

In general the meeting seemed to favor an extension of the use of moving pictures in instruction recognizing that moving pictures are not now universal in application to teaching.

W. I. FREEL,
Secretary.

NECROLOGY

WILLIAM HENRY WHEELER, Assistant Professor of Civil Engineering at Washington University, St. Louis, Missouri, died on December 30, 1933, after a six-days' illness of pneumonia.

Professor Wheeler was born June 14, 1890, received his public school education in St. Louis and his technical training at Ohio Northern University where he graduated in 1914. After three years of experience in various engineering organizations, he joined the U. S. Army, 23d Engineers, and saw sixteen months of active field service in France.

He joined the faculty of Washington University, St. Louis, as Instructor in Civil Engineering in September, 1920, and was promoted to the rank of Assistant Professor in 1924. During his years of teaching he kept in close contact with engineering problems and spent his summer vacations actively employed in some engineering capacity.

From 1929 to 1931 inclusive, he was materials testing engineer for the St. Louis County Highway Department, and was in full charge of scientific control of concrete for two and a quarter million square yards of pavement.

In June, 1931, and again in the summer of 1933, he headed expeditions into a remote area of Labrador for a St. Louis syndicate to determine the importance of the gold deposits there.

He will be remembered by his students, faculty colleagues, and engineer friends as one keenly alive to new ideas, an enthusiastic teacher, and one who carried high ideals in engineering work into practical application.

BOOK REVIEW

The Economics of Mining. THEODORE JESSE HOOVER, Professor of Mining and Metallurgy, Dean of the School of Engineering, Stanford University. Stanford University, California, Stanford University Press, 1933. 526 pages. $6.00.

The three parts of this work, approximately equal in length, treat respectively: valuation, organization, and management. So far as specific mineral products are in mind, only non-ferrous metals are covered, but much of the material relates to mining in general, and portions are applicable to all industry.

Valuation, the subject of Part I, includes the procedure of sampling, the computations associated with sampling, and the geologic, economic, and personal factors involved in valuation. The detailed mathematics of valuation is left to other writers. Part II, Organization, treats the types of ownership suited to a mining property, the methods of financing, and other features of the business that are of special interest to the investor. Management, as covered by Part III, relates to the local mine staff and working force, their efficiency and their welfare. An exhaustive bibliography follows each of the twenty-seven chapters.

Although a technical book, it is unusually readable, and a layman will find many of the chapters interesting. The author's personality is reflected in the work in a way that is rare in technical literature. Illustrative facts and brief stories, drawn from his own experience and that of others, give the book a quality that is unique.

The volume is to be regarded primarily as a textbook for mining students, outlining the economics of their field, but to experienced engineers as well, it should prove interesting and profitable to read.

R. M. BLACK.